PCA CASE NO. 2023-01

INDUS WATERS TREATY ARBITRATION (PAKISTAN V. INDIA)

Final Comments of Pakistan on Particular Matters Addressed in Procedural Order No. 14

25 February 2025

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I. INTRODUCTION

1.1. By Procedural Order No. 14 (Further Directions Regarding the Production of Papers and Other Evidence; Further Comments by the Parties on Particular Matters), dated 6 December 2024 ("**PO14**"), the Court of Arbitration invited the Parties to address certain matters, as follows:

(a) **Historic Practice with Respect to the Calculation of Maximum Pondage**: In paragraph 2.4 of PO14, the Court invited comments on the historic practice of the Parties with respect to the calculation of maximum Pondage pursuant to

Annexure D, Paragraph 8(c), in light of the views expressed by the Commissioners for Indus Waters in correspondence referenced by the Court. The Court further invited the Parties to elaborate on the extent to which their respective Commissioners for Indus Waters during these periods had previously been involved in the negotiation of the Treaty and the relevance, if any, of the involvement of such persons in the practice of the Parties in the implementation of the Treaty.

(b) **Near-term effects of Sediment Accumulation on Pondage**: In paragraph 2.7 of PO14, the Court invited comments on the near-term effects of sediment accumulation on Pondage for HEPs on the Western Rivers, and its relevance when interpreting the Treaty's provisions on the calculation of Pondage.

(c) **Comments on available data on sediment accumulation**: In paragraph 2.9 of PO14, the Court invited comments on the available data (including in the public domain) on the actual or estimated sedimentation accumulation rates of reservoirs on the Western Rivers, including the Baglihar HEP.

1.2. By letter dated 19 December 2024, in response to an application by Pakistan concerning the deadline for the submission of comments, the Court provided that final comments on the matters raised in paragraphs 2.4, 2.7 and 2.9 of PO14 should be submitted by Friday, 21 February 2025, but noted that, in the event that either Party was in a position to submit preliminary comments on the matters addressed in paragraphs 2.1–2.4 and 2.5–2.7, the Court would be grateful to receive such comments by Saturday, 25 January 2025.

1.3. In response to the Court's request, Pakistan submitted Preliminary Comments on the matters raised by the Court on 25 January 2025 ("**Preliminary Comments**"). Following an extension of the deadline, at Pakistan's request, for the submission of final comments, the present submission sets out Pakistan's **Final Comments** on the issues raised by the Court in PO14.

II. THE COURT'S QUESTION ON PONDAGE

2.1. In paragraphs 2.1–2.4 of PO14, the Court raised various issues concerning the Parties' historic practice with respect to the calculation of maximum Pondage. In this regard, the Court highlighted the views expressed by the Parties' respective Commissioners for Indus Waters in itemised correspondence. With reference to these views, the Court invited the Parties to comment on the historic practice of the Parties with respect to the calculation of maximum Pondage pursuant to Annexure D, Paragraph 8(c), and to elaborate on the extent to which their respective Commissioners, in the period in question, had previously been involved in the negotiation of the Treaty and the relevance, if any, of the involvement of such persons in the practice of the Parties in the implementation of the Treaty.

2.2. Pakistan addresses these issues below in two parts: **first**, the role of Pakistan's Commissioner for Indus Waters, Mian Khalil-Ur-Rahman, as part of Pakistan's delegation in the negotiations that led to the conclusion of the Treaty. This section also addresses the evolution in the approach to, and the formula in respect of, the calculation of maximum Pondage during the negotiations; and, **second**, Pakistan's comments on the correspondence identified by the Court in PO14.

A. THE ROLE OF MIAN KHALIL-UR-RAHMAN IN THE TREATY NEGOTIATIONS

2.3. As noted in Pakistan's Preliminary Comments, Mian Khalil-ur-Rahman (who is usually referred to in the *travaux préparatoires* simply as "**Mr Khalil**"), was Pakistan's Commissioner for Indus Waters ("**PCIW**") from 1964 to 1971.[1] He also served for a period as part of Pakistan's delegation in the negotiations that led to the conclusion of the Treaty and appears at one point to have been deputy head of that delegation. Before addressing the evolution in the approach to the calculation of maximum Pondage during the negotiations, and the significance, if any, that attaches to Mr Khalil's participation in the negotiations, Pakistan turns first to address Mr Khalil's role in the negotiations.

[1] Mr Khalil also acted as the acting PCIW from March-August 1961, which included his participation in the first meeting of the Permanent Indus Commission in March 1961 (*see* Record of the 1st Meeting of the Permanent Indus Commission, 28-30 March 1961, dated 30 March 1961, **Exhibit P-0647.01**); his name also appears in correspondence from that period (*see*, e.g., Letter No. 2(1)/61-IC re HEP from the ICIW to the PCIW, 31 March 1961, **Exhibit P-0649.1742**; and Letter No. WT(14)/(82-A)/PCIW from the PCIW to the ICIW, 25 August 1961, **Exhibit P-0649.1754**). Mr Khalil again acted briefly as the PCIW in June 1962 (*see*, e.g., Letter No. F.14(11)/61-IC from the ICIW to the PCIW, 4 June 1962, **Exhibit P-0649.1793**; and Letter No. WT(38/1)/(400-A)/PCIW from the PCIW to the ICIW, 27 June 1962, **Exhibit P-0649.1802**). Another individual from Pakistan's Treaty negotiation delegation, Mohammad Abdul Hamid, also served as PCIW in the 1960–1964 period. However, given that India made no proposals during Mr Hamid's tenure under Paragraph 8 of Annexure D, this has no bearing on the Court's questions in PO14.

1. Mr Khalil as a member of Pakistan's negotiating delegation

2.4. Pakistan's review of the *travaux préparatoires* of the Treaty and the Wheeler Archive show that Mr Khalil was a member of Pakistan's delegation in the final stages of the negotiations in 1959–1960, although his name is also referenced elsewhere as a member of the delegation in the pre-negotiations talks in 1954 as a member of the Central Engineering Authority.[2] In this earlier role, he was a member of the Indus Basin Advisory Board, a pre-negotiation body established by Pakistan in consultation with the Bank to determine the works necessary to transfer its historical water dependence from the Eastern to Western Rivers.[3] Mr Khalil is listed as a member of the Board at its final meeting on 18 September 1959.[4]

2.5. Within the negotiations themselves, Mr Khalil is recorded as attending multiple meetings as part of Pakistan's delegation. He was active in the negotiation of the Heads of Agreement of 15 September 1959 ("**the 1959 Heads of Agreement**"),[5] appearing in the minutes of multiple meetings in August and September 1959.[6]

2.6. The 1959 Heads of Agreement were followed by the draft treaty texts of 24 November 1959 ("**the November 1959 Draft**")[7] and 9 December 1959 ("**the December 1959 Draft**").[8] Further negotiations then produced additional drafts on 20 April 1960 ("**the April 1960 Draft**")[9] and 8 June 1960 ("**the June 1960 Draft**").[10] Mr Khalil appears to have been less engaged during the preparation of these instruments, but he continued to be involved in the

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[2] U. Z. Alam, "Water Rationality: Mediating the Indus Waters Treaty", Ph.D. Thesis, Geography Department, University of Durham, September 1998, **Exhibit P-0245 (resubmitted)**, p. 131.

[3] World Bank, "Indus Waters Settlement Plan", 18 April 1960, **Exhibit P-0277**, ¶ 45.

[4] And as having prepared a note on the distribution of irrigation resources between the Indus and its tributaries: Memorandum of the Final Meeting of the Indus Basin Advisory Board, 18 September 1959, **Exhibit P-0656**, ¶¶ 1, 6.

[5] Indus Waters, Heads of Agreement, 15 September 1959 ("**Heads of Agreement 1959**"), **Exhibit P-0136**.

[6] *See* e.g. World Bank, Minutes of Meeting, 10 August 1959, **Exhibit P-0455**; World Bank, Minutes of Meeting, 14 August 1959, **Exhibit P-0457**; World Bank, Minutes of Meeting (Pakistan representatives), 15 August 1959, **Exhibit P-0458**; World Bank, Minutes of Meeting, 21 August 1959, **Exhibit P-0657**; World Bank, Minutes of Meeting (Pakistan representatives), 23 August 1959, **Exhibit P-0464**; World Bank, Minutes of Meeting, 25 August 1959, **Exhibit P-0469**; World Bank, Minutes of Meeting, 27 August 1959, **Exhibit P-0470**; World Bank, Minutes of Meeting, 10am, 2 September 1959, **Exhibit P-0471**; World Bank, Minutes of Meeting, 3pm, 2 September 1959, **Exhibit P-0472**; World Bank, Minutes of Meeting (Pakistan representatives), 3 September 1959, **Exhibit P-0473**; World Bank, Minutes of Meeting, 8 September 1959, **Exhibit P-0474**.

[7] Indus Waters Treaty draft (for circulation within the working group only) [without Annexures] ("**November 1959 draft**"), 24 November 1959, **Exhibit P-0137**.

[8] Indus Waters Treaty 1960 draft of 9 December 1959 [without Annexures] ("**December 1959 draft**"), **Exhibit P-0139**.

[9] Indus Waters Treaty 1960 draft of 20 April 1960 [without Annexures] ("**April 1960 draft**"), **Exhibit P-0143**.

[10] Indus Waters Treaty 1960, Draft of 8th June 1960 [without Annexures] ("**June 1960 draft**"), **Exhibit P-0151**.

Treaty negotiations[11] and is recorded as attending several meetings over this period.[12]

2.7. Following the conclusion of the Treaty, Mr Khalil served as the second Pakistan Commissioner for Indus Waters ("**PCIW**"), from 8 June 1964 to 5 October 1971. Unsurprisingly, the main focus of his engagement during this period appears to have been the Transition Period concerning the Eastern Rivers, addressed in Article II(5)-(9) and Annexure H of the Treaty, which was the principal focus of the Parties' attention in the early years following the Treaty's conclusion.[13]

2.8. The Transition Period was the period provided for in the Treaty during which Pakistan would wean itself from its dependency on the Eastern Rivers, as required by Article IV(1). Pursuant to Article II(6) of the Treaty, the Transition Period began on 1 April 1960 and was scheduled to end on 31 March 1970, unless extended under the provisions of Part 8 of Annexure H. Pursuant to Paragraph 53 of Annexure H, the maximum period of extension of the Transition Period was to 31 March 1973.

2.9. Annexure H of the Treaty is complex and detailed, covering 33 of the Treaty's 85 pages. Given its huge importance, much of the discussion between the Commissioners during the Transition Period was taken up with the implementation of the terms of Article II(6)–(9), Annexure H and associated provisions of Article IV of the Treaty, an endeavour complicated by the Second Pakistan-India War of 1965. Despite the obvious challenges, no extension to the Transition Period was required under Annexure H, and it ended on 31 March 1970, as anticipated, during Mr Khalil's tenure.

2. The evolution of the formula for calculation of maximum Pondage during the Treaty negotiations

2.10. As part of Pakistan's negotiating team, Mr Khalil would doubtlessly have been aware of the Parties' evolving approach to the calculation of maximum Pondage over the course of the negotiations. This evolution was addressed in the course of the Hearing on the First Phase

[11] The archive of preparatory material surrounding these negotiations is comprised largely of correspondence to or signed by the delegation leaders (in Pakistan's case, Ghulam Mueenuddin) and other high-ranking officials, internal memoranda, and the drafts themselves.

[12] World Bank, Minutes of Meeting, 10 November 1959, **Exhibit P-0658**; World Bank, Minutes of Meeting prepared by Covington and Burling, 10 November 1959, **Exhibit P-0659**; World Bank, Minutes of Meeting, 11 March 1960, **Exhibit P-0660**; World Bank, Minutes of Meeting, 25 March 1960, **Exhibit P-0661**.

[13] Indus Waters Treaty 1960, **PLA-0001**, Article II(5).

of the Merits,[14] but is usefully sketched out in more detail here with a view to shining a light on the developments to which Mr Khalil would have been party and apprehended at the time.

2.11. The starting point is the 1959 Heads of Agreement, by which the Parties first indicated the design criteria for run-of-river HEPs under what would become Annexure D in the text of the Treaty as finally adopted. **Paragraph 3** of Annex B of the 1959 Heads of Agreement provided as follows:

> Except as provided in paragraph 14 below, the design of any "Run-of-River" plant shall conform to the following criteria […]
>
> b. The volume between the maximum and minimum levels of the operating pool **shall not exceed that required to meet the daily or weekly load fluctuations as the case may require**. […][15]

2.12. **Paragraph 14**, in turn, dealt with the concept of Small Plants. In particular, it provided that:

> Subject to the provisions of paragraph 18 below, the provisions of paragraphs 3, 4, 5, 6, and 7 above shall not apply to a run-of-river hydro-electric plant which conforms to the following criteria:
>
> a. it is not located on the main stem of any of the three Western Rivers;
>
> b. no storage is involved in connection with the plant, **except the forebay pondage required for daily and weekly load fluctuations** and the storage incidental to the diversion structure;
>
> c. the crest of the diversion structure across the tributary, or the top level of the gates, if any, shall not be higher than 20 feet above the main bed of the tributary at the site of the structure;
>
> d. the aggregate maximum designed discharge through the turbines does not exceed 300 cusecs.[16]

2.13. So far as Pondage was concerned, therefore, the 1959 Heads of Agreement treated regular Plants and Small Plants in accordance with the same fundamental principle, namely, that Pondage was to be calculated by reference to "daily and weekly load fluctuations". In the case of a Small Plant, storage was further limited by the caps on design discharge and dam

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[14] Transcript of Hearing for the First Phase on the Merits, Day 2 (9 July 2024), p. 56, line 20 – p. 61, line 16 (Ms Rees-Evans).
[15] Heads of Agreement 1959, **Exhibit P-0136**, Annex B, ¶ 3(b) (emphasis added).
[16] *Id*..

height in Paragraphs 14(c) and (d).

2.14. The November and December 1959 Drafts were circulated without annexures, although the December 1959 Draft indicated that Annexure D would (in due course) deal with "Construction of Hydroelectric Plants by India on the Western Rivers".[17] A draft of Annexure D first appeared alongside the April 1960 Draft ("**April 1960 Annexure D Draft**").[18] Of material importance, this text reflected a <u>significant</u> change in the Parties' approach to Pondage.

2.15. In **Paragraph 5**, the definitions section of the April 1960 Annexure D Draft, it was provided that:

> As used in this Part of this Annexure: […]
>
> (c) "Pondage" means storage of only sufficient magnitude to meet fluctuations in the discharge of the turbines arising from fluctuations in the daily and weekly loads of the plant. […]
>
> (i) "Firm Power" means the hydro-electric power corresponding to the minimum 10-daily discharge available at the site in a year of average supply. […][19]

2.16. As will be immediately appreciated, this April 1960 Annexure D Draft formulation was a significant break from the approach to Pondage in the 1959 Heads of Agreement and November-December 1959 Drafts – providing the basis for what was to become Paragraphs 2(c) and (i) of Annexure D as eventually concluded.

2.17. **Paragraph 7** of the April 1960 Annexure D Draft, in turn, set out the **design criteria** for run-of-river HEPs. On the calculation of maximum Pondage, it provided:

> Except as provided in Paragraph 17, the design of any Run-of-River Plant shall conform to the following criteria: […]
>
> (c) The maximum Pondage in the Operating Pool shall not exceed twice the Pondage required for Firm Power […][20]

2.18. As will be evident, this corresponds broadly to the formulation that was eventually

[17] December 1959 draft, **Exhibit P-0139**, Contents.
[18] Annexure D, Generation of Hydro-Electric Power by India on the Western Rivers, draft of 23 April 1960 ("**April 1960 draft of Annexure D**"), **Exhibit P-0476**.
[19] *Id.*, ¶ 5(c), (i).
[20] *Id.*, ¶ 7(c).

included as Paragraph 8(c) of the Annexure D text of the Treaty that was ultimately adopted.

2.19. **Paragraph 17** of the April 1960 Annexure D Draft addressed the concept of what came to be known in due course as "Small Plants". It provided:

> Subject to the provisions of Paragraph 21, the provisions of Paragraphs 7, 8, 9, 10, 11, and 12 shall not apply to a Run-of-River Plant which conforms to the following criteria (hereinafter referred to as a Small Plant):
>
> (a) it is not located on the Indus Main, the Jhelum Main or the Chenab Main;
>
> (b) the aggregate maximum designed discharge through the turbines does not exceed 300 cusecs;
>
> (c) no storage is involved in connection with the plant, except the Pondage and the storage incidental to the diversion structure;
>
> (d) the crest of the diversion structure across a Tributary, or the top level of the gates, if any, shall not be higher than 20 feet above the mean bed of the Tributary at the site of the structure.[21]

2.20. As will be evident from the preceding, the April 1960 Annexure D Draft rested on a new approach to the (then) putative bargain between the Parties on Pondage – one that would form the basis of the Treaty as eventually concluded. The concept at the heart of this new approach was Firm Power.

(a) With respect to **new run-of-river Plants** other than Small Plants (for ease of reference, hereafter described as "**regular Plants**"):

i. The load-based concept of Pondage was confined to a definition in Paragraph 5(c) of the Draft. Whilst it was still to be read into the design criterion of Paragraph 7(c) of the Draft, it was no longer the main focus of that provision and therefore not the key determinant for calculation of maximum Pondage.

ii. That position was taken up by the new concept of Firm Power introduced in Paragraph 5(i) of the Draft, which pegged the capacity of the Operating Pool not to the load that India chose to put on the Plant, having regard to its installed capacity, but to the historical hydrology of the

[21] *Id.*, ¶ 17.

river, a value that was incapable of manipulation by either Party.

(b) With respect to **Small Plants**, as the load-based concept of Pondage remained a definition in Paragraph 5(c), it was the only relevant limitation on the calculation of Pondage in Paragraph 17(c), and so doubled as a design criterion. Whilst there was no Firm Power equivalent in Paragraph 17(c), objective limitations were (as in the 1959 Heads of Agreement) nonetheless placed on India by limiting the maximum design discharge to 300 cusecs (Paragraph 17(b)) and the height of the dam to 20 feet above the bed of the river (Paragraph 17(d)).

2.21. What is evident from the April 1960 Annexure D Draft, therefore, is the change in approach of the negotiators to (intentionally) root the concept of maximum Pondage for a regular Plant in an **objective hydrological limit** – i.e., Firm Power.[22] This was a significant departure from the load-based concept of Pondage that is found in the 1959 Heads of Agreement, which remained in place for Small Plants only.

2.22. The scheme just described was essentially maintained in the draft of Annexure D that appeared alongside the June 1960 Draft ("**June 1960 Annexure D Draft**"). The concepts in the April 1960 Annexure D Draft were either maintained or subject to non-material change. The structure of the Annexure was, however, modified. In particular:[23]

(a) The definitions in Paragraph 5 of the April 1960 Annexure D Draft were moved to Paragraph 2 of the June 1960 Annexure D Draft.

(b) The design criteria of regular Plants in Paragraph 7 of the April 1960 Annexure D Draft were moved to Paragraph 8 of the June 1960 Annexure D Draft.

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[22] As Pakistan explained in its Post-Hearing Submission dated 1 November 2024, ¶¶ 2.117–2.128, properly understood, both the Annexure D, Paragraphs 2(c) and (i) definitions of Pondage and Firm Power play a role in Paragraph 8(c), and its operating concept of "twice the Pondage required for Firm Power".

- The latter (Firm Power) provides an **outer limit** to the Operating Pool. In any case, India can never exceed twice the Live Storage it requires for Firm Power (i.e., twice the Live Storage necessary to ensure that all daily inflow passes through the HEP's turbines at the Firm Power rate).
- The former (Pondage) provides an **inner limit** to the Operating Pool. Having calculated the outer limit, by reference to Firm Power only, if the Operating Pool so fixed provides more Live Storage than India needs to meet daily and weekly fluctuations in the load on the Plant, then the Operating Pool is limited to that needed to meet those fluctuations, and no more. India is not entitled to Live Storage that it cannot usefully deploy for power production.

[23] Indus Waters Treaty 1960, Annexure D: Generation of Hydro-Electric Power by India on the Western Rivers (Article III(2)(d)), draft of 6th June 1960 ("**June 1960 draft of Annexure D**"), 6 June 1960, **Exhibit P-0478**.

(c) The design criteria of Small Plants in Paragraph 17 of the April 1960 Annexure D Draft were moved to Paragraph 18 of the June 1960 Annexure D Draft.

2.23. The final change to the scheme for the calculation of maximum Pondage came on 6 June 1960, and was contemporaneous with the June 1960 Annexure D Draft. This was an Indian suggestion to revise the definition of Firm Power in Paragraph 2(i) of the June 1960 Annexure D Draft to make it more precise. In particular, India proposed that Paragraph 2(i) should read:

> "Firm Power" means the hydro-electric power corresponding to the minimum mean discharge at the site of a plant, the minimum mean discharge being calculated as follows:
>
> > The average discharge for each 10-day period (1st to 10th, 11th to 20th and 21st to the end of the month) will be worked out for each year in which discharge data, whether observed or estimated, are proposed to be studied for the purpose of design. The mean of the yearly values for each 10-day period will then be worked out. The lowest of the mean values thus obtained will be taken as the minimum mean discharge.[24]

2.24. This text was accepted by Pakistan and appears as Paragraph 2(i) in Annexure D of the Treaty as finally concluded, but with a coda enabling yet further precision:

> The studies will be based on data for as long a period as available but may be limited to the latest 5 years in the case of Small Plants (as defined in Paragraph 18) and to the latest 25 years in the case of other Plants (as defined in Paragraph 8).[25]

2.25. The above developments tell a story of how the Parties, in the course of negotiating the Treaty, sought:

(a) to remove loading by the Plant operator, combined with the installed capacity of the Plant, as the key determinant in the calculation of Pondage for India's run-of-river HEPs on the Western Rivers (aside from Small Plants); and

(b) to substitute it with an objective metric that could not be the subject of easy manipulation as it was connected to the historical hydrology of the watercourse in question – i.e., Firm Power, corresponding to the minimum mean discharge

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[24] Indus Waters Treaty 1960, Annexure D (Draft dated 6th June, 1960), Amendments proposed by India, **Exhibit P-0379**, Amendment 7.
[25] Indus Waters Treaty, **PLA-0001**, Annexure D, Paragraph 2(i).

("**MMD**") at the site of a Plant.

2.26. This change in approach made (and makes) abundant good sense. As India itself has recognised in the context of Pondage, "[i]n the meticulously drafted Treaty, […] subjectivity is beyond comprehension".[26]

2.27. In **Annex I** to these Comments, Pakistan presents a side-by-comparison of the 1959 Heads of Agreement and the Treaty as concluded. This shows clearly how much the Parties' approach to the calculation of maximum Pondage changed over time. As noted at the Hearing, what this shows is "the marginalisation of load in the calculation of Pondage, and the steadily increasing importance of Firm Power", and that "in transitioning from the relevance of load factor to Firm Power, [the Parties] made Pondage more restricted".[27]

2.28. In September 1960, upon conclusion of the Treaty, Mr Khalil would undoubtedly have been well aware of this evolution in approach.

3. The significance of Mr Khalil's involvement in the Treaty negotiations

2.29. Pulling the above together, there is very little of direct and material significance that can be gleaned from Mr Khalil's involvement in the Treaty negotiations. As noted, he would undoubtedly have been aware of and well understood the significant evolution away from load, as a criterion in the calculation of maximum Pondage, to hydrology and Firm Power as the controlling factors, and have understood the objective limit that was being put in place as regards India's Pondage storage capacity. This appreciation must be measured against his attitude subsequently as PCIW, and that of his successors, in the correspondence identified by the Court in PO14. It is to this that Pakistan now turns.

B. Pakistan's comments on the correspondence identified by the Court

2.30. The Court has invited comments from the Parties on the correspondence identified in PO14 relating to the application of the Treaty in the 1968–1994 period, i.e., the period in which India began to propose new HEP projects under the terms of Annexure D.[28]

[26] Record of the 113th Meeting of the Permanent Indus Commission, 20–21 March 2017, dated 29 March 2018, **Exhibit P-0545**, ¶ 28.
[27] Transcript of Hearing for the First Phase on the Merits, Day 2 (9 July 2024), p. 61, lines 6-13 (Ms Rees-Evans).
[28] Procedural Order No. 14, ¶¶ 2.3–2.4.

1. The evolution of Pakistan's approach to the calculation of maximum Pondage under the Treaty in the period in question (1968–1994)

2.31. Pakistan has carefully reviewed the correspondence identified by the Court. For purposes of analysis, it can be broken into three temporal phases:

(a) In **Phase 1** (1968–1971), India proposed two tiny HEPs with miniscule Pondage – the Stakna and Sumbal[29] HEPs. The Operating Pools of these HEPs were calculated on the basis of a small installed capacity and daily load, resulting in negligible Live Storage. Whilst Mr Khalil, then PCIW, did not actively contest the premise of India's calculations, he also did not expressly affirm them. Instead, he ensured that India's calculations were accurate and that no further Live Storage was concealed in its HEP designs.

(b) In **Phase 2** (1971–1979), India first proposed the Lower Jhelum HEP, utilising the same principles as the Stakna and Sumbal HEPs. Habib-ur-Rahman, Mr Khalil's successor as PCIW, protested the design of the Lower Jhelum HEP's Operating Pool on precisely the same basis as Pakistan would later protest the much larger Baglihar HEP, i.e., that India was using Plant loading and installed capacity as the basis of its Pondage calculation, and not Firm Power. He made the same protest with respect to the Chinani HEP.

(c) In **Phase 3** (1979–1994), Mr Habib and his successors maintained their protests against India's approach to Pondage calculation with respect to a number of HEPs. Whilst Pakistan would ultimately accept that these Plants could be built, the principled basis of its objection to the calculation of Pondage never went away. And, eventually, India exceeded Pakistan's tolerance by proposing the Baglihar HEP, a 450 MW HEP with an Operating Pool that dwarfed every design that India had previously put forward. It was in response to this egregious overreach that Pakistan, for the first time, engaged Article IX(2) of the Treaty and referred the Baglihar HEP to a Neutral Expert for assessment.

[29] Once constructed, known as Upper Sindh-I HEP.

(a) India's proposed low-Pondage HEPs: 1968–1971

2.32. Phase 1 of the correspondence identified by the Court took place in the period 1968–1971, straddling the end of the Article II(5), Annexure H Transition Period. On 9 and 11 September 1968, respectively, the Indian Commissioner for Indus Waters ("**ICIW**") proposed the Stakna and Sumbal HEPs.[30]

2.33. The Stakna and Sumbal HEPs are also the first projects for which India advanced its defective interpretation of Paragraph 8(c) of Annexure D, relying on the installed capacity of, and load on, the Plant as the principal determinants of its Pondage entitlement.[31]

2.34. Several features of these HEPs are worth noting.

(a) **First**, their installed capacity was miniscule. The Sumbal HEP had an installed capacity of 22 MW.[32] The Stakna HEP was even smaller, with an installed capacity of only 4 MW.[33]

(b) **Second**, India had calculated Pondage on these HEPs on the basis of a <u>daily</u> load pattern, for a typical day, and did not purport to take account of weekly load.[34]

(c) **Third**, taking these two factors together, India represented that the two HEPs required very little Pondage "for Firm Power" under its interpretation of Paragraph 8(c) of Annexure D: 151 acre-ft (0.19 Mm^3) for the Sumbal HEP,[35] and 74.3 acre-ft (0.09 Mm^3) for the Stakna HEP.[36] When doubled, pursuant to Paragraph 8(c), this resulted in a claimed maximum Pondage of 302 acre-ft (0.37 Mm^3) for the Sumbal HEP and 148.6 acre-ft (0.18 Mm^3) for the Stakna

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[30] Letter No. F.4(1)/66-IC from the ICIW to the PCIW, 9 September 1968 (Stakna), **Exhibit P-0649.1730**; and Letter No. 4(13)/65-IC from the ICIW to the PCIW, 11 September 1968 (Sumbal), **Exhibit P-0649.1731**.

[31] Counter-Memorial of Government of India (*Baglihar* Neutral Expert proceedings), 23 September 2005, **Exhibit P-0547/BR-0008**, p. 119 ("the Stakna Hydro-Electric Plant on the Indus river, which was the **first hydro-electric plant for which calculations for the Operating Pool were communicated to Pakistan**.") (emphasis added).

[32] Letter No. 4(13)/65-IC from the ICIW to the PCIW, 11 September 1968, **Exhibit P-0649.1731**, p. 7, ¶ 4(i).

[33] Counter-Memorial of the Government of India (*Baglihar* Neutral Expert proceedings), 23 September 2005, **Exhibit P-0547/BR-0008**, Annexure 2.6, p. 130.

[34] Letter No. F.4(1)/66-IC from the ICIW to the PCIW, 24 December 1969, **Exhibit P-0649.0163**, ¶ 3(b); and Letter No. 4(13)/65-IC from the ICIW to the PCIW, 10 February 1969, **Exhibit P-0649.0140 (resubmitted)**, p. 5.

[35] Letter No. 4(13)/65-IC from the ICIW to the PCIW, 10 February 1969, **Exhibit P-0649.0140 (resubmitted)**, p. 5.

[36] Letter No. F.4(1)/66-IC from the ICIW to the PCIW, 24 December 1969, **Exhibit P-0649.0163**, pp. 4-5, ¶ 3(b).

HEP.

(d) **Fourth**, even with this miniscule, claimed Pondage entitlement, India proposed to install an even smaller Operating Pool in each HEP: 162 acre-ft (0.2 Mm^3) for the Sumbal HEP,[37] and 110.1 acre-ft (0.14 Mm^3) for the Stakna HEP.[38]

2.35. Given the tiny numbers in issue, it appears that Mr Khalil was not minded to challenge the premise of the ICIW's calculation. This is entirely understandable in circumstances in which the end of the Transition Period was fast approaching, with Annexure H issues no doubt at the forefront of the Commissioners' minds.

2.36. For Mr Khalil to have challenged the premise of the ICIW's calculation at that point would have given rise to a dispute that would have been meaningless in substance at a point at which the Parties were focused on other issues concerning the implementation of the Treaty. Rather than do so, Mr Khalil appears to have confined his inquiries on Pondage to ensuring that India had applied its own methodology correctly. This was chiefly done through:

(a) requesting that the actual calculations used by India to calculate the Operating Pool be provided;[39]

(b) ensuring that the MMD was calculated as accurately as possible,[40] and

(c) confirming that all Live Storage within each HEP design was accounted for in determining whether India's allocated Pondage was within its professed entitlement.[41]

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[37] Letter No. 4(13)/65-IC from the ICIW to the PCIW, 10 February 1969, **Exhibit P-0649.0140 (resubmitted)**, p. 5.

[38] Letter No. F.4(1)/66-IC from the ICIW to the PCIW, 24 December 1969, **Exhibit P-0649.0163**, pp. 4-5, ¶ 3(b).

[39] Letter No. WT(16)/(2202-A)/PCIW from the PCIW to the ICIW, 5 November 1968, **Exhibit P-0649.0136**, p. 3, ¶ 3(b); and Letter No. WT(16)/(2201-A)/PCIW from the PCIW to the ICIW, 5 November 1968, **Exhibit P-0649.0137**, p. 3, ¶ 3(b).

[40] Letter No. WT(16)/(2202-A)/PCIW from the PCIW to the ICIW, 5 November 1968, **Exhibit P-0649.0136**, p. 2, ¶ 2(b); Letter No. WT(16)/(2201-A)/PCIW from the PCIW to the ICIW, 5 November 1968, **Exhibit P-0649.0137**, p. 2, ¶ 2(b); Letter No. WT(16)/(2453-A)/PCIW from the PCIW to the ICIW, 18 April 1970, **Exhibit P-0649.0168**, pp. 2-3, ¶ 2(b); Letter No. WT(16)/(2488-A)/PCIW from the PCIW to the ICIW, 30 May 1970, **Exhibit P-0649.0171**, ¶ 4; and Letter No. WT(16)/(2726-A)/PCIW from the PCIW to the ICIW, 28 August 1971, **Exhibit P-0649.0215**, ¶ 3.

[41] Letter No. WT(16)/(2202-A)/PCIW from the PCIW to the ICIW, 5 November 1968, **Exhibit P-0649.0136**, pp. 2-3, ¶¶ 3(a), (b); Letter No. WT(16)/(2201-A)/PCIW from the PCIW to the ICIW, 5 November 1968, **Exhibit P-0649.0137**, pp. 2-3, ¶¶ 3(a), (b); Letter No. WT(16)/(2453-A)/PCIW from the PCIW to the ICIW, 18 April 1970,

2.37. At the same time, however, on no occasion did Mr Khalil expressly accept that the ICIW's approach to the calculation of Pondage was consistent with the language of the Treaty.

2.38. Given their size, neither the Sumbal nor Stakna HEPs appear to have provoked serious disagreement between the Parties.

2.39. In concluding its observations on the Sumbal and Stakna HEPs, Pakistan underscores that consideration of Pondage in respect of these Plants spanned a period of three years, at the end of the Transition Period, concerned two Plants the storage in respect of which was miniscule (on any calculation of Pondage), and in respect of which India's methodology rested on the use of a daily load pattern, rather than a weekly load. Pakistan's lack of express disagreement with India's approach to the calculation of maximum Pondage in respect of these Plants during this period is therefore inconsequential.

(b) Pakistan takes issues with India's approach to the calculation of maximum Pondage: 1971–1979

2.40. Pakistan's position changed following the Transition Period, by which time it had successfully shifted its dependence away from the Eastern Rivers to the Western Rivers.

2.41. On 21 November 1974, the ICIW notified Mr Habib, the then-PCIW, of a new HEP governed by Annexure D: the Lower Jhelum HEP. This was a 105 MW Plant, designed to accommodate a relatively small Operating Pool of 779.5 acre-ft (0.96 Mm^3).[42] However, the claimed maximum Pondage on India's approach was 1,677 acre-ft (2.07 Mm^3),[43] which when doubled pursuant to Paragraph 8(c) gave a purported entitlement of 3,354 acre-ft (4.14 Mm^3).

2.42. Whilst the Lower Jhelum HEP was relatively small by comparison to India's modern Plants, the significant increase in India's claimed entitlement – exceeding that to which India would be entitled to under Pakistan's current approach[44] – appears to have prompted Mr Habib to abandon his predecessor's forbearance. In his 28 January 1976 response to India's

Exhibit P-0649.0168, p. 3, ¶ 3(a); and Letter No. WT(16)/(2488-A)/PCIW from the PCIW to the ICIW, 30 May 1970, **Exhibit P-0649.0171**, ¶ 6.

[42] Letter No. F.4(1)/62-IC(IT) from the ICIW to the PCIW, 21 November 1974, **Exhibit P-0649.0268**, p. 2, ¶ 3(b).

[43] *Id*., p. 29, Enclosure 14.

[44] The MMD at the Lower Jhelum HEP site was calculated as 2,763ft^3/sec (78.25m^3/sec): Letter. No. F.4(1)/62-IC(IT) from the ICIW to the PCIW, 21 November 1974, **Exhibit P-0649.0268**, p. 29, Enclosure 14. Under Pakistan's current approach, the maximum Pondage to which the Lower Jhelum HEP would be entitled is 3.38Mm^3.

notification of the Lower Jhelum HEP design, Mr Habib took specific issue with the ICIW's approach to Pondage calculation:

> The generation pattern has to be related to the Operating Pool provided at the site of the Plant. The calculations for the Operating Pool furnished in Encl. 14 of your letter dated 21st November 1974 **do not depict the actual variations through the turbines which are proposed to be met with the pondage provided and, therefore, appear to be hypothetical**. It may please be appreciated that the capacity of the Operating Pool is **to correspond to the Firm Power which can be actually generated at a time when the river is carrying the [MMD]**.[45]

2.43. The ICIW responded in his letter of 12 May 1976, declaring only that "[t]o the extent that the Pondage that could be provided at site falls short of the requirement of the load curve, there will no doubt be a constraint on the peaking capability of the Plant".[46] For Mr Habib, this was no answer at all. On 26 July 1976, he wrote in reply:

> Your observations imply that the calculations for the operating pool are to be based on a daily load curve which can not be met with the pondage provided at a time when the river is carrying the [MMD]. I do not agree with the view and reiterate my earlier observation.[47]

2.44. Mr Habib's comments are **substantively identical** to those made by Pakistan in 1992 in response to the Baglihar HEP. The Court will recall that, on 12 August 1992, the then-PCIW, Mr Abdul Rahim, wrote to his counterpart:

> The criterion (c) laid down in Paragraph 8 of Annexure D to the Treaty provides that "The maximum Pondage in the Operating Pool shall not exceed twice the Pondage required for Firm Power". […] Firm Power defined in Paragraph 2(i) of Annexure D to the Treaty means: "[…] the hydro-electric power corresponding to the [MMD] at the site of a plant […]". However, the calculations for the 'Pondage' supplied vide Annexure III to your letter under reference is based on **a very hypothetical load curve, which provides for a Firm Power, which does not correspond to the [MMD] intimated by you. The Pondage provided in the design of the Plant is therefore, more than twice the Pondage required for Firm Power**. Therefore, the design of the Plant contravenes the criterion (c) laid down in Paragraph (8) of Annexure D to the Treaty.[48]

2.45. In its Post-Hearing Submission, Pakistan observed that Mr Rahim's 12 August 1992

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[45] Letter No. WT(85)/(3487-A)/PCIW from the PCIW to the ICIW, 28 January 1976, **Exhibit P-0649.0342**, pp. 5-6, ¶ 3(c)(iii) (emphasis added).
[46] Letter No. F.4/1/62-IC(IT) from the ICIW to the PCIW, 12 May 1976, **Exhibit P-0649.0356 (resubmitted)**, p. 3, ¶ 3(c)(iii).
[47] Letter No. WT(85)/(3567-A)/PCIW from the PCIW to the ICIW, 26 July 1976, **Exhibit P-0649.0361**, p. 3, ¶ 3(c)(iii).
[48] Letter No. WT(127)/(5293-A)/PCIW from the PCIW to the ICIW, 12 August 1992, **Exhibit P-0649.2047**, ¶ 5.

letter reflected a "crystallis[ation of] the dispute between the Parties on the calculation of maximum Pondage".[49] In view of the correspondence identified by the Court concerning the Lower Jhelum HEP, this was an understatement. The Parties' dispute over the proper interpretation of Paragraph 8(c) of Annexure D in reality crystallised far **earlier**, in the statements of Mr Habib just referenced.

2.46. That Mr Habib was concerned by India's Live Storage overreach is further reflected in his response to the Chinani HEP, details of which were first communicated to Pakistan on 14 March 1978.[50] Despite its miniscule Operating Pool of 40 acre-ft (0.05 Mm^3),[51] Mr Habib was alert to the risks of a load-based approach to maximum Pondage, and so protested the premise of India's calculation. On 4 August 1979, he wrote:

> [T]he generation pattern has to be related to the Operating Pool provided at the site of the Plant. But in case of the Plant under reference calculations for the Operating Pool do not depict the actual variations through the turbines, which are proposed to be met with the pondage provided and, therefore, **appear to be hypothetical. The permissible capacity of the Operating Pool is to correspond to the Firm Power which can be actually generated at the time the river is carrying the [MMD]**.[52]

2.47. As the Court will appreciate, this is again materially identical to the protest that Mr Habib raised with respect to the Lower Jhelum HEP in 1976 and Mr Rahim raised with respect to the Baglihar HEP in 1992.

(c) Pakistan's objections to India's approach increase: 1979–1994

2.48. Mr Habib's objections were repeated in subsequent PCIW correspondence, not only to the end of Mr Habib's tenure, on 28 December 1985, but into the tenure of Mr Rahim, who served as PCIW until 19 October 1993. While the expression of Pakistan's objections took on a shorthand form – that India's Pondage calculation was "hypothetical", or based on a "hypothetical load curve", i.e., not corresponding to the Firm Power that the HEP could actually generate – the essence of the objections was the same. Objections of this character were made with respect to the 390 MW Dul Hasti HEP in 1984;[53] the 37.5 MW Parnai HEP in

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[49] *COA* Pakistan's Post-Hearing Submission, 1 November 2024, ¶ 2.17.
[50] Letter No. F.4(7)/64-IC(IT) from the ICIW to the PCIW, 14 March 1978, **Exhibit P-0649.0403 (resubmitted)**.
[51] *Id.*, p. 2, ¶ 4.
[52] Letter No. WT(14)/(4023-A)/PCIW from the PCIW to the ICIW, 4 August 1979, **Exhibit P-0649.0425**, ¶ 2.
[53] Letter No. WT(104)/(4565-A)/PCIW from the PCIW to the ICIW, 11 February 1984, **Exhibit P-0649.0493**, Observations, ¶ 3(b)(iv): "it appears that the calculations given […] are hypothetical".

1990;[54] and the Baglihar HEP in 1992.[55]

2.49. In circumstances in which objections were not made with respect to a given HEP governed by Paragraph 8(c) of Annexure D, this appears to be because the Parties were engaged in some other, equally fundamental, disagreement concerning Live Storage. Thus:

(a) The 105 MW Upper Sindh-II HEP was a downstream expansion of the Sumbal HEP with a small Operating Pool of 0.4 Mm^3.[56] As with the Sumbal HEP, Pakistan's principal concern at this point appears to have been that there was unaccounted-for Live Storage within the HEP's design,[57] and that India had not indicated the figure for calculation of the MMD, such that its calculations could not be verified.[58] Another question of note was how the releases from the Operating Pool of the Sumbal HEP would be accounted for by India.[59] India, further, had not indicated either the Firm or Secondary Power that the design was expected to supply.[60]

(b) The 3.75 MW Kargil HEP was billed as a "Mini Hydel Project" with an Operating Pool of 0.11 Mm^3.[61] India failed to provide essential dimensions and clarifications for the Plant such that Pakistan could not verify the permissible Pondage. It had also failed to indicate the Firm and Secondary Power. There also remained the issue of unaccounted for Live Storage elsewhere in the design.[62]

(c) The 480 MW Uri-I HEP was billed by India as having no Operating Pool at

[54] Letter No. WT(16)/(5138-A)/PCIW from the PCIW to the ICIW, 14 April 1990, **Exhibit P-0649.0703**, Observations, ¶¶ 3(b) and (c)(i): "The calculations for the Operating Pool […] are hypothetical".
[55] Letter No. WT(127)/(5293-A)/PCIW from the PCIW to the ICIW, 12 August 1992, **Exhibit P-0649.2047**, ¶ 5: "the calculations for the 'Pondage' supplied […] is based on a very hypothetical load curve".
[56] Letter F.11(2)/82-I.T/135, 18 May 1984 from the ICIW to the PCIW, **Exhibit P-0649.0500 (resubmitted)**, p. 32.
[57] Letter No. WT(16)/(4618-A)/PCIW from the PCIW to the ICIW, 18 August 1984, **Exhibit P-0649.0503**, Observations, ¶¶ 3(a)(v), (b) & (c)(iii).
[58] *Id.*, Observations, ¶¶ 3(b) & (c)(i), (ii).
[59] *Id.*, Observations, ¶¶ 3(b) & (c)(iv).
[60] *Id.*, Observations, ¶ 4(i).
[61] Letter No. F.3(5)/83-I.T/227 from the ICIW to the PCIW, 30 January 1986, **Exhibit P-0649.0534 (resubmitted)**, p. 3, ¶ 3(c).
[62] Letter No. WT(38/2)/(4747-A)/PCIW, 20 April 1986 from the PCIW to the ICIW, **Exhibit P-0649.0543**, Observations, ¶¶ 3(b) & (c)(i)–(iv), 4(i).

all.[63] Pakistan nevertheless perceived unaccounted for Live Storage within the design arising from the power and hydel tunnels, which it required India to acknowledge.[64] There were also issues with the calculation of the MMD.[65]

2.50. The final HEP identified by the Court in PO14, the Asthan Nallah HEP, was a Small Plant subject to the design criteria in Paragraph 18 of Annexure D and not Paragraph 8. The PCIW's objection, therefore, in the context of that project, that "the capacity of Operating Pool has to be calculated on the actual load curve",[66] was completely appropriate and in line with the load-based concept of Pondage in the design criteria for Small Plants. The PCIW's statements in this context have no bearing on Pakistan's position with respect to the Firm Power based concept of Pondage in the design criteria for regular Plants, pursuant to Paragraph 8 of Annexure D.

2.51. What is apparent from the correspondence canvassed above is that, following Mr Habib's initial concerns with the Lower Jhelum HEP, Pakistan's objections to India's methodology for the calculation of Pondage abated somewhat before increasing markedly with India's notification of the Baglihar HEP in 1992.[67] To understand why, one need only look at the Baglihar HEP design, which represented a significant departure from India's historic practice on HEP design and Pondage in several respects.

(a) **First**, the Operating Pool of the Baglihar HEP as designed was a colossal **37.5 Mm^3**.[68]

(b) **Second**, in order to produce Pondage of this magnitude under India's methodology, the Baglihar HEP combined an installed capacity of 450 MW with a **weekly**, rather than daily, load curve.[69]

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63 Letter No. 3(26)/72-I.T./1, 16 January 1989 from the ICIW to the PCIW, **Exhibit P-0649.0645 (resubmitted)**, p. 1.
64 Letter No. WT(103)/(5082-A)/PCIW from the PCIW to the ICIW, 7 September 1989, **Exhibit P-049.0677**, ¶¶ 3, 5.
65 Letter No. WT(103)/(5052-A)/PCIW, 8 June 1989 from the PCIW to the ICIW, **Exhibit P-0649.0656 (resubmitted)**, ¶ 3(iii).
66 Letter No. WT(15)/(5021-A)/PCIW from the PCIW to the ICIW, 5 December 1988, **Exhibit P-0649.0637**, Observations, para. 3(b)(iii).
67 Letter No. 3/1/84-I.T/597 from the PCIW to the ICW, 20 May 1992, **Exhibit P-0585**.
68 *Id.*, p. 3.
69 Counter-Memorial of the Government of India (*Baglihar* Neutral Expert proceedings), 23 September 2005, **Exhibit P-0547/BR-0008**, Annexure 2.6, p. 130. For all of India's previous HEPs, save Dul Hasti, maximum Pondage was calculated on the basis of daily, not weekly, Plant loading.

(c) **Third**, whilst in many other cases, India had not sought to use the entirety of its claimed Pondage, in the case of the Baglihar HEP, India proposed to use almost the **entirety** of its purported allocation of 37.57 Mm^3.[70]

2.52. The Baglihar HEP shared some of these features with the Dul Hasti HEP, which was first notified to Pakistan in 1978. Like the Baglihar HEP, the Dul Hasti HEP had a relatively large installed capacity (390 MW), a relatively large Operating Pool (8 Mm^3), and Pondage that was calculated on the basis of a weekly loading.[71] As noted, Mr Habib lodged a protest against that HEP and its "hypothetical" Pondage calculation in 1984,[72] even if that protest was not especially emphatic. The reason for this, as hypothesised in Pakistan's Post-Hearing Submission, was that a single HEP with an Operating Pool of 8 Mm^3 was not significant enough to warrant Mr Habib referring the matter to a third party.[73] But when the Baglihar HEP was notified, it evidently became clear to Mr Rahim, the then-PCIW, that the Dul Hasti HEP was not a 'one-off' but was rather reflective of a new Indian approach to HEP design on the Western Rivers. Mr Rahim's 12 August 1992 letter of protest in respect of the Baglihar HEP[74] was accordingly followed a month later by an enhanced and near-identical letter of protest in respect of the Dul Hasti HEP.[75]

2.53. In due course, the Baglihar HEP would be referred to a Neutral Expert by Mr Rahim's successor, Syed Jamait Ali Shah, starting the Parties on the course that has led them to the present proceedings.

2. India's explanation of the Parties' prior practice on the calculation of Pondage, as contained in its Counter-Memorial in the *Baglihar* proceedings, is inaccurate and self-serving

2.54. In paragraph 2.4 of PO14, the Court invited the Parties to "elaborate on […] the relevance, if any, of the involvement of such persons [participants in the Treaty negotiations

[70] *Id.*.
[71] Letter No. F.16(4)/62-IT from the ICIW to the PCIW, 3 July 1978 from the ICIW to the PCIW, **Exhibit P-0649.0408 (resubmitted)**, pp. 3, 6, 8.
[72] Letter No. WT(104)/(4565-A)/PCIW from the PCIW to the ICIW, 11 February 1984, **Exhibit P-0649.0493**, Observations, ¶ 3(b)(iv).
[73] *COA* Pakistan's Post-Hearing Submission, 1 November 2024, ¶ 2.22.
[74] Letter No. WT(127)/(5293-A)/PCIW from the PCIW to the ICIW, 12 August 1992, **Exhibit P-0649.2047**, ¶ 5.
[75] Letter No. WT(104)/(5304-A)/PCIW from the PCIW to the ICIW, 14 September 1992, **Exhibit P-0649.0773**, ¶ 6.

who subsequently became Commissioners for Indus Waters] in the practice of the Parties in the implementation of the Treaty". The Court specifically referenced, in that context, a portion of India's Counter-Memorial in the *Baglihar* Neutral Expert proceedings titled "Accepted Practice for Pondage Calculation". In that discussion, India advanced a limited analysis of handpicked correspondence between the Commissioners regarding India's approach to calculating the maximum Pondage in the design for its Western Rivers HEPs between 1968 and 1990.

2.55. In its Counter-Memorial, India suggested:

(a) that it adopted the "same standard and consistent procedure" for Pondage calculation in all Annexure D HEP designs during the relevant period;

(b) that the "basic concept" underlying its Pondage calculation was "suggested in explicit terms by the [PCIW]" in his letter objecting to certain design parameters of the Stakna HEP in 1969;

(c) that Pakistan conveyed its general acceptance of India's "procedure for the calculations for the Operating Pool" in the context of the Dul Hasti HEP in a letter from 1978; and

(d) that the Pondage calculation for the Baglihar HEP and India's other HEPs on the Western Rivers was therefore "based on accepted interpretation of the provisions of the Treaty evidenced by 'subsequent practice' [of the Parties] which has been consistently followed over the years".[76]

2.56. As will be apparent from Pakistan's review of the historical record in the preceding section of these Comments, it is plain that India's analysis and claims were (and are) inaccurate and self-serving. This appreciation is further confirmed by an examination of the documents that underpin India's account.

2.57. **First**, India based its argument on just <u>two</u> communications from the PCIW between 1968-1990 relating to the Stakna and Dul Hasti HEPs, and even then, presented

[76] Counter-Memorial of the Government of India (*Baglihar* Neutral Expert proceedings), 23 September 2005, **Exhibit P-0647/BR-0008**, section 2.6, pp. 118-120.

decontextualised excerpts from those communications.

2.58. With respect to the Stakna HEP, as explained earlier in these Comments,[77] while the PCIW did not actively contest the premise of India's calculation, he also did not expressly affirm it. Instead, he sought to ensure that India's calculation was accurate on its own terms. And, as noted, in the period in which the Stakna HEP was notified to Pakistan, the Parties were engaged on more fundamental issues under the Treaty relating to the Annexure H Transition Period. Further, given India's miniscule, claimed Pondage entitlement for the Stakna HEP, based on daily load variations of the Plant, the PCIW evidently concluded that he should not raise objections to India's calculation methodology.

2.59. Additionally, when one looks at the 5 November 1978 letter from the PCIW, which India cites, it is evident that the PCIW said nothing like what India suggested.[78] In the passage to which India points in its *Baglihar* Counter-Memorial, the PCIW notes that India has not provided the information that it was required to provide under Paragraph 4(h) of Appendix II to Annexure D, namely information concerning "[d]ischarge proposed by the passed through the Plant, initially and ultimately, on account of the daily and weekly load fluctuations" – and asks that it be provided.[79] The implication by India that this request that India comply with its data provision obligations under the Treaty can be taken as an acceptance of India's approach to the calculation of Pondage has no basis whatever.[80]

2.60. The 21 September 1978 letter concerning the Dul Hasti HEP, also relied upon by India,[81] similarly provides no foundation to support the Pakistan's alleged "acceptance of the procedure for the calculations for the Operating Pool".[82] In the excerpt cited by India, the PCIW does not comment on the appropriateness of India's Pondage calculation but rather

[77] *See* paragraphs 2.32-2.39 above.
[78] Letter No. WT(16)/(2201-A)/PCIW from the PCIW to the ICIW, 5 November 1968, **Exhibit P-0649.0137**.
[79] *Id*., p. 4, ¶ 4(h): "Variations in the discharge on account of weekly load fluctuations have not been supplied. These may please be supplied now".
[80] Counter-Memorial of the Government of India (*Baglihar* Neutral Expert proceedings), 23 September 2005, **Exhibit P-0547/BR-0008**, section 2.6, p. 119.
[81] *See* Counter-Memorial of the Government of India (*Baglihar* Neutral Expert proceedings), **Exhibit P-0547/BR-0008**, p. 119, which cites to Letter No. WT(104)/(3926-A)/PCIW from the PCIW to the ICIW, 21 September 1978, **Exhibit P-0649.0411**, Observations, ¶ 3(b)(iv) ("The calculations for the Operating Pool contained in Appendix II to your letter under reference indicate a capacity of 6878 acre feet. Whereas the capacity of Operating Pool given against item 3(b) is 6500 acre feet. Appendix II to your letter under reference may, therefore, be amended to correspond to the figure of 6500 Acre Feet.")
[82] Counter-Memorial of the Government of India (*Baglihar* Neutral Expert proceedings), **Exhibit P-0547/BR-0008**, p. 119.

requests India to address an inconsistency in the figure for the Operating Pool volume given at two different points of its design notification for the Dul Hasti HEP. Further, contrary to India's assertion, the PCIW does in fact object to India's Pondage calculation in the 21 September 1978 letter on the grounds that it cannot verify India's calculation of the Operating Pool because India had supplied an inadequate contoured survey map and failed to provide either the figure or calculations for the MMD.[83]

2.61. Additionally, the story of the Dul Hasti HEP does not end with Pakistan's 1978 correspondence. There are subsequent communications from 1984 and 1992, addressed above,[84] in which the PCIW, with increasing force, objected to the calculation of Pondage in the HEP design because the calculation was "hypothetical"[85] and "based on a very hypothetical load curve, which provided for a 'Firm Power', which did not correspond to the [MMD]".[86]

2.62. In preparing its submissions in the *Baglihar* proceedings, India presumably reviewed the entire record of correspondence between the Commissioners in support of its contention that Pakistan had accepted that its approach to the calculation of maximum Pondage was correct. Yet the two letters referred to in India's Counter-Memorial were evidently the only support it could muster for its argument. Read in full, however, and in context, they do not support India's case.

2.63. **Second**, and as the above review of the full documentary record shows, the Parties were in significant and sustained disagreement on the approach to Pondage calculation from an early point in their exchanges. India ignores in its analysis the correspondence between the Commissioners on the Lower Jhelum, Chinani, and Parnai HEPs. In those cases, the PCIW objected to India's approach to calculating its claimed Pondage entitlement on the basis that the calculations were "hypothetical" and not based on Firm Power, as required by the Treaty.[87]

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[83] Letter No. WT(104)/(3926-A)/PCIW from the PCIW to the ICIW, 21 September 1978, **Exhibit P-0649.0411**, Observations, ¶ ¶ 3(a), b(i) and (iii).
[84] *See* paragraphs 2.48, 2.52 above.
[85] Letter No. WT(104)/(4565-A)/PCIW from the PCIW to the ICIW, 11 February 1984, **Exhibit P-0649.0493**, Observations, ¶ 3(b)(iv).
[86] Letter No. WT(104)/(5304-A)/PCIW from the PCIW to the ICIW, 14 September 1992, **Exhibit P-0649.0773**, ¶ 6.
[87] Letter No. WT(85)/(3487-A)/PCIW from PCIW to ICIW, 28 January 1976, **Exhibit P-0649.0342**, ¶ 3(c)(iii); Letter No. WT(14)/(4023-A)/PCIW from the PCIW to the ICIW, 4 August 1979, **Exhibit P-0649.0425**, ¶ 2; and Letter No. WT(16)/(5138-A)/PCIW from PCIW to ICIW, 14 April 1990, **Exhibit P-0649.0703**, Observations, ¶¶ 3(b) and (c)(i).

2.64. India also notified designs for the Upper Sindh-II, Kargil, and Uri-I HEPs in that period. As explained above, the Parties were engaged in other fundamental disagreements concerning Live Storage on those projects, and the Uri-I HEP was billed as having no Operating Pool at all.[88]

2.65. **Third**, in its submissions in the *Baglihar* proceedings, India asserted that it adopted the "same and consistent procedure" in its approach to the calculation of its Pondage entitlement. On the face of India's own submissions, this is wrong. At Annexure 2.6 of India's Counter-Memorial in the *Baglihar* proceedings, it sets out the details of its claimed Pondage entitlement in seven HEP designs.[89] For the Stakna, Lower Jhelum, Upper Sindh-II and Parnai HEPs, India's Pondage calculation is "based on daily load variation", while for the Dul Hasti and Baglihar HEPs (i.e., the Plants with the largest claimed Pondage entitlement), the Pondage calculation was "based on weekly load variations".

2.66. The choice of using either "daily" or "weekly" load variations is critical to the ultimate value for the claimed Pondage entitlement of a HEP. As Pakistan addressed above, it is not a coincidence that for the two Plants with the largest claimed Pondage entitlement (and therefore eliciting the strongest objections from Pakistan) India based its calculation on "weekly" load variations.[90] India itself thus had an inconsistent approach to calculating its claimed Pondage entitlement. India's assertion, therefore, that there was an accepted practice between the Parties that constituted "subsequent practice" with respect to the implementation of the Treaty is contradicted by the record.

2.67. **Fourth**, and in light of the foregoing, India's argument on the "Accepted Practice for Pondage Calculation" was plainly a self-serving and *ex post facto* position, manufactured for the purposes of the *Baglihar* proceedings. There is no correspondence of which Pakistan is aware – and India does not cite any such correspondence in its Counter-Memorial or Rejoinder in the *Baglihar* proceedings – in which the ICIW complained that Pakistan was reneging on or departing from a previously accepted approach to the calculation of Pondage between the Parties. It appears for the first time in India's *Baglihar* pleadings.

[88] *See* paragraph 2.49 above.
[89] Counter-Memorial of the Government of India (*Baglihar* Neutral Expert proceedings), 23 September 2005, **Exhibit P-0547/BR-0008**, Annexure 2.6, p. 130.
[90] *See* paragraphs 2.51 and 2.52 above.

2.68. It is worth noting that Pakistan expressly rejected India's position in the *Baglihar* proceedings, contending then, as it does now, that the two communications cited by India do not "support[] [its] contention" and were presented "out of context", and that there was no "explicit or implicit acceptance by Pakistan that 'maximum Pondage' is to be calculated with reference to expected load variations".[91] India's response in its Rejoinder mostly repeated what was said in its Counter-Memorial.[92] This issue does not appear to have been a material point of contention, and no mention is made of the historic practice of the Parties with respect to Pondage calculations in the *Baglihar* Determination.

3. Conclusions to be drawn from the correspondence identified by the Court

2.69. The following conclusions emerge from the preceding examination of the correspondence identified by the Court in PO14.

(a) **First**, the period in which Pakistan might be said not to have raised an express objection to India's approach to the calculation of maximum Pondage under Paragraph 8(c) of Annexure D spans three years (between 1968–1971) at the end of the Transition Period.

i. This period covered the first two HEPs proposed by India in which Paragraph 8(c) was engaged, the Sumbal and Stakna HEPs.

ii. Even so, India appears to have well-understood the nature of Pakistan's objections to its approach to the calculation of maximum Pondage. When Mr Habib pointed out his objections to the New Jhelum HEP in 1976, and when these objections were amplified by Mr Rahim in 1992 in respect of the Dul Hasti and Baglihar HEPs, the ICIW did not suggest either that the PCIW was going back on Pakistan's previous acceptance of India's methodology or that he was departing from a previous consensus. Rather, the ICIW engaged in a defence of India's approach.

iii. While India did eventually advance an argument that Pakistan had

[91] Reply of the Government of Pakistan to the Counter Memorial by Government of India (*Baglihar* Neutral Expert proceedings), 25 January 2006, **Exhibit P-0547/BR-0011**, pp. 111-112.
[92] Rejoinder of the Government of India (*Baglihar* Neutral Expert proceedings), 20 March 2006, **Exhibit P-0547/BR-0012**, pp. 107-108.

acquiesced on the issue of the calculation of maximum Pondage, that argument first appeared in India's Counter-Memorial in the *Baglihar* Neutral Expert proceedings in 2005. By this point, however, Pakistan had been protesting the impermissibility of India's approach to maximum Pondage for nearly 30 years.

(b) **Second**, Mr Khalil adopted the position he took for self-evidently sensible reasons.

i. The Stakna and Sumbal HEPs each had very small installed capacity. Further, India had calculated their proposed Live Storage on the basis of a daily load curve. This produced a miniscule Pondage entitlement – which India diminished still further with its design for the respective Operating Pools. Mr Khalil therefore confined himself to ensuring that India's calculations were accurate, rather than challenging the premise of those calculations at a point at which the Parties were preoccupied with other fundamental issues under the Treaty.

ii. At the point at which it became clear that India was set on designing HEPs on the basis of significant claims to Pondage – the first being the Lower Jhelum HEP in 1976 – the then-PCIW, Mr Habib, challenged the premise of India's calculation. This objection was maintained for new Indian HEPs over the intervening years prior to India's exorbitant claims in respect of the Baglihar HEP in 1992, which compelled Pakistan to place the issue before the Neutral Expert in the context of that Plant.

(c) **Third**, India's approach to the calculation of maximum Pondage and HEP design changed materially over time.

i. India's initial approach to the calculation of maximum Pondage relied on the use of a daily load curve, combined with a small installed capacity. This tended to produce a reduced claim to Pondage entitlement, particularly where the HEP in question was on a tributary of the Western Rivers as opposed to a main stem.

ii. With the Dul Hasti HEP, however, India switched to a weekly load curve when calculating Pondage. This produced materially increased Live Storage, which heightened Pakistan's concern with India's approach, reliant on installed capacity and load.

iii. Pakistan's concerns crystallised sharply with the Baglihar HEP and its 37.5 Mm^3 Operating Pool. While this was only 60 MW larger than the Dul Hasti HEP, in terms of then-installed capacity, its Operating Pool was over 4.5 times larger. Of all the HEPs proposed by India between 1968 and 1992, the Baglihar HEP Operating Pool accounted for 78% of their total Live Storage.

(d) **Fourth**, the correspondence in issue affirms Pakistan's consistent case on Pondage and helps explain why India's position **cannot** be correct.

i. Under India's approach, by manipulating the load on a Plant, together with its installed capacity, India would be able to set the Pondage "required for Firm Power" under Paragraph 8(c) more or less where it likes.

ii. As the Chairman of the Court recognised in the Hearing, India's approach to these matters of load and installed capacity allows for "a lot of play in the joints that India would take advantage of",[93] a statement with which Pakistan agrees.[94]

iii. As India itself has recognised, the technical criteria for Pondage calculation under Annexure D are intended to remove the ability for either Party to manipulate the size of India's Operating Pools to its advantage: "[i]n the meticulously drafted Treaty, […] subjectivity is beyond comprehension".[95]

93 Transcript of Hearing for the First Phase on the Merits, 16 July 2024 (Day 7), p. 101, line 21 – p. 102, line 6 (The Chairman).
94 Transcript of Hearing for the First Phase on the Merits, 16 July 2024 (Day 7), p. 102, line 7 (Dr Miles).
95 Record of the 113th Meeting of the Permanent Indus Commission, 20–21 March 2017, dated 29 March 2018, **Exhibit P-0545**, ¶ 28.

2.70. For the avoidance of doubt, in the event that the Court considers that there is any basis to the suggestion that Pakistan in some manner acquiesced in India's use of the waters of the Western Rivers by way of a less than fully articulated objection to India's methodology of calculation of maximum Pondage, Pakistan considers that that use of the waters by India was not in accordance with a correct interpretation of the Treaty and that, pursuant to Article IV(14) of the Treaty, India cannot have acquired, by reason of Pakistan's conduct, any right to a continuance of such use.

III. THE COURT'S QUESTIONS ON SEDIMENT MANAGEMENT

3.1. In paragraph 2.5 of PO14, the Court recalled its interest, during the Hearing, on the length of time it would take for sedimentation to reach the sill-level of the low-level outlet for reservoirs on the Western Rivers, such as the Baglihar HEP.

3.2. As noted in Pakistan's Preliminary Comments, Dr Morris provided an initial response to this question during the Hearing in which he explained that, because Himalayan rivers include a considerable load of sediments which settle rapidly, a delta will form and advance into the reservoir. One sediment management approach is to retard delta movement towards the intakes.[96] He further explained that the aim of sediment management is to develop an equilibrium profile while sustaining usable storage capacity.[97]

3.3. In general, the time required for sediments to reach the sill-level of a HEP's outlet will vary depending on the reservoir's size, geometry, and sediment load. The extent to which Pondage is subject to sediment accumulation also depends on the way the reservoir is designed and operated. Pakistan makes two points in this regard:

(a) The experience of the Salal HEP, which accumulated sediment up to the spillway crest level within five years, is attributable to poor design.[98]

(b) The effects of continuous high-level operation, illustrated through models of sediment accumulation at the Baglihar HEP, will cause sediment to deposit within and deplete the storage capacity of the Operational Pool. However,

[96] Transcript of Hearing for the First Phase on the Merits, 11 July 2024 (Day 4), pp. 47, line 2 – p. 50, 4 (Dr Morris).
[97] *Id.*, p. 56, line 8 – p. 58 line 4 (Dr Morris).
[98] *See also* **Annex III**.

managing reservoir sedimentation by seasonal sluicing can preserve capacity in the Operating Pool for over 100 years (per India's modelling discussed below in relation to **Figure 4.11** and at **Annex II**).

3.4. **First**, sediment impacts on operation of the **Salal HEP** are attributable to poor design and operational strategies. Although the 1970 letter from the ICIW indicated that Salal was to be built as a Run-of-River Plant to be operated at a constant water level, without an Operating Pool,[99] India constructed the 690 MW Plant with low-level outlets.[100]

3.5. Since the Salal HEP does not incorporate live storage,[101] the only challenge that sedimentation poses at the HEP is abrasion of the turbines. Yet India did not provide desanders (also called desilting basins) or a skimming weir to minimise sediment entry into the deep power intakes (the "silt exclusion basin" described at the Kol HEP in **Annex III** hereto), and this at a time when the need for desilting at run-of-river Plants was well known.[102]

3.6. Following objections by Pakistan,[103] the low-level outlets of the Salal HEP were blocked off.[104] India attributes the filling of the Salal reservoir with sediment to the unavailability of low-level outlets.[105] However, in practice, the filling of the reservoir with

[99] Letter No. F.4(10)/63-IC from the ICIW to the PCIW, 30 April 1970, **Exhibit P-0649.0169 (resubmitted)**.
[100] *See* Agreement Between the Government of the Islamic Republic of Pakistan and the Government of the Republic of India Regarding the Design of the Salal Hydro-Electric Plant on the Chenab River Main, 14 April 1978, **PLA-0053**; and Letter No. WT(86)/(5533-A)/PCIW from the PCIW to the ICIW, 31 January 1996, **Exhibit P-0649.0844**.
[101] Agreement Between the Government of the Islamic Republic of Pakistan and the Government of the Republic of India Regarding the Design of the Salal Hydro-Electric Plant on the Chenab River Main, 14 April 1978, **PLA-0053** (indicating that the operating pool is nil).
[102] Letter No. F.4(10)/63-IC from the ICIW to the PCIW, 30 April 1970, **Exhibit P-0649.0169 (resubmitted)**; Letter No. F.4(10)/63-IC(IT) from the ICIW to the PCIW, 19 February 1975, **Exhibit P-0649.0281**; and Agreement Between the Government of the Islamic Republic of Pakistan and the Government of the Republic of India Regarding the Design of the Salal Hydro-Electric Plant on the Chenab River Main, 14 April 1978, **PLA-0053**.
[103] Letter No. WT(86)/(2495-A)/PCIW from the PCIW to the ICIW, 17 July 1970, **Exhibit P-0649.0172**; Letter No. WT(86)/(2544-A)/PCIW from the PCIW to the ICIW, 24 December 1970, **Exhibit P-0649.0183**; and Record of the 43rd Meeting of the Permanent Indus Commission, 26-30 April 1976, dated 30 April 1976, **Exhibit P-0647.43 (resubmitted)**. Pakistan notes that the Record of the 42nd Meeting of the Permanent Indus Commission, 28 March-2 April 1976, dated 2 April 1976, **Exhibit P-0647.42** refers to, on the second last page, two notes handed over by the PCIW that "incorporate[s] [PCIW's] observations already made during previous discussions on the location of the intake for turbines and the provision of outlets below the Dead Storage Level". Pakistan has been unable to locate these notes in its records.
[104] Agreement Between the Government of the Islamic Republic of Pakistan and the Government of the Republic of India Regarding the Design of the Salal Hydro-Electric Plant on the Chenab River Main, 14 April 1978, **PLA-0053**; and Record of the 83rd General Tour of Inspection by the Permanent Indus Commission, 30 July-4 August 1988, dated 4 August 1988, **Exhibit P-0648.17**.
[105] India's written additional comments on its presentation (Salient Features of Salal Dam and Comments on Prof. Albert Rooseboom's Report), 24 November 2006, **Exhibit P-0547/BR-0015**, section 1.4, p. 15 of PDF ("The

sediment would not have been a genuine concern beyond its impact on turbine abrasion, given that Salal HEP was designed without live storage. In reality, the plant suffers from design deficiencies, including a failure to provide desanding facilities and a failure to adopt a design that protected the power intakes from sediment by arranging sluices below the intakes.[106]

3.7. It is noteworthy that, despite having the outlets blocked, the Salal HEP has been able to maintain about 12 to 13 Mm^3 of capacity in the reservoir under its current configuration.[107] Until September 2023, India provided Pakistan with limited (once-daily) information on the water level in this reservoir, but not on the extent of any short-duration drawdown in the water level via operation of spillway gates. Nonetheless, as Pakistan has previously drawn to the Court's attention, it appears that drawdown flushing operations took place at Salal in May 2024, presumably using the gated spillway.[108]

3.8. **Second**, **continuous high-level operation** will increase the rate of sediment accumulation. If India was to hold the reservoirs of its HEPs at the Full Pondage Level during months of high flow and high sediment load, this would place the entire capacity of the Operating Pool below the water surface and lead to significant sedimentation therein.

3.9. The effectiveness of seasonal emptying of the operating pool for sediment sluicing was made clear in the *Baglihar* Neutral Expert proceedings in which India's expert, DHI, presented a one-dimensional (1-D) model simulating 100 years of reservoir sedimentation.[109] Results of the sluicing analysis are summarised in **Figures 4.10** and **4.11** (the original numbering) showing the rapid progression of sediment into the reservoir, with the bed profile reaching the sill level of the sluice gates after 30 years, yet the operating pool is preserved. In contrast, when sluicing was not simulated most of the Operating Pool filled with sediment over the same

absence of any sediment management system such as sluice spillway, **under sluices**, etc. has caused serious problems in the operation of the project […]. The provision of sluice spillway and **bottom outlets** would have helped in maintaining the sedimented reservoir bed much below the power intake invert and eliminating the entry of bed load as well as water with high concentration of larger particles near the bed into the power intake.") (emphasis added).

[106] Comments of Government of Pakistan on the Final Draft Determination by the Neutral Expert, 24 October 2006, **Exhibit P-0547/BR-0044**, Appendix 1, pp. 6-11.

[107] B. Joshi, et al. (2021). "Sediment Management Practices in NHPC's Power Stations." ICOLD 2021 Workshop, Sediment Management in Reservoirs for Sustainable Development, **Exhibit P-0662**, p.5.

[108] Transcript of Hearing for the First Phase on the Merits, 8 July 2024 (Day 1), p. 149, line 23 – p. 150, line 13 (Pakistan's Commissioner for Indus Waters); Letter No. WT(86)/(8165-A)/PCIW from the PCIW to the ICIW, 28 May 2024, **Exhibit P-0576**; and Video, "Salal Power Station appeals people away from Chenab River," *JKupdate*, 28 May 2024, **Exhibit P-0575**.

[109] DHI, 'Baglihar Sedimentation Study' (*Baglihar* Neutral Expert Proceedings), **Exhibit P-0547/BR-0021**, section 4.5.3, pp. 27-30.

time period.

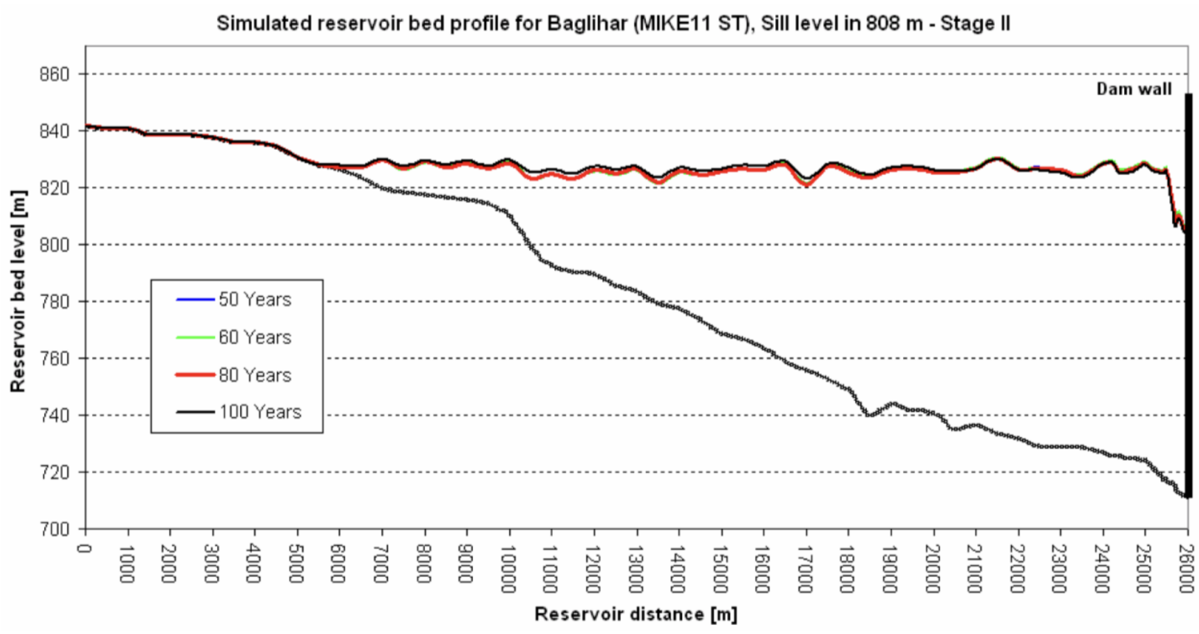

Figure 4.10 – Simulated Reservoir Profile for 1, 2, 5, 10, 15, 20, 25, 30, 35 and 40 Years with a Sill Level at 808m – Stage II with a Discharge of 860m^3/s in the Intake[110]

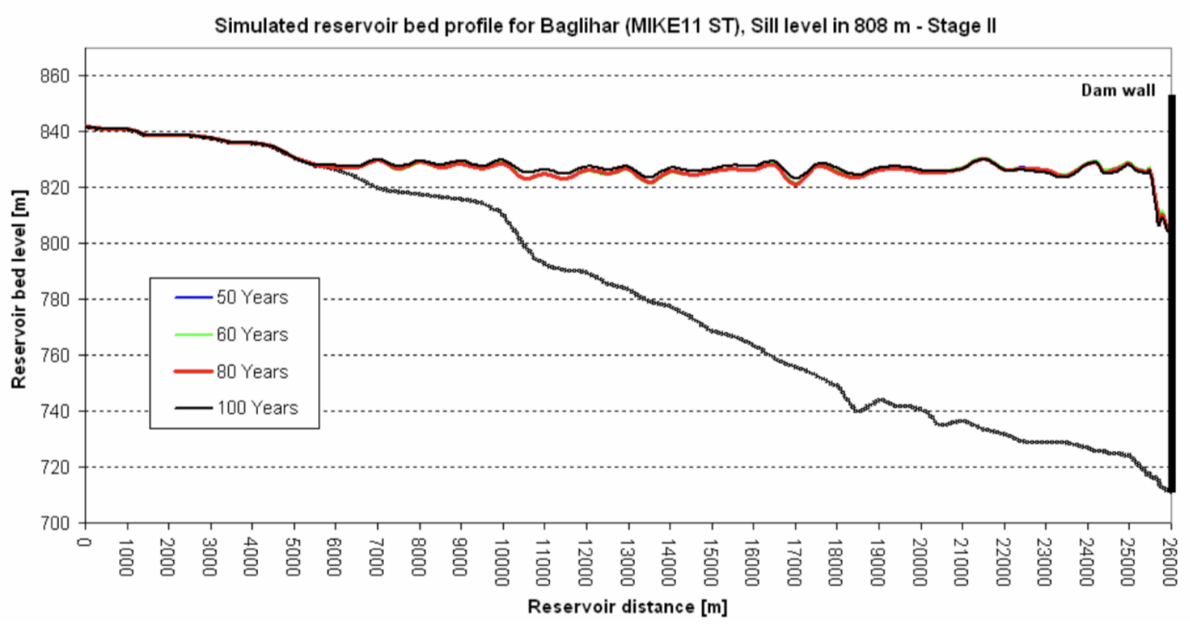

Figure 4.11 – Simulated Reservoir Profile for 50, 60, 80 and 100 Years with a Sill Level at 808m Stage II with a Discharge of 860m^3/s in the Intake[111]

[110] *Id.*, p. 28.
[111] *Id.*, section 4.5.2, p. 29.

3.10. The seasonal operating rule used by DHI in the sluicing simulation at Baglihar is shown in **Table 4.1** (original numbering).

The minimum operation level (MOL) of the reservoir is 835 m and the full supply level (FSL) is 840 m. The spillway gates and the turbines are operated according to the criteria in table 4.1

Table 4.1 Criteria for setting spillway gate levels and turbines discharge

	Spillway gate criteria	**Turbine flow**
Period \ Condition	*Reservoir level*	*Discharge [m^3/s]*
Monsoon	835 m	430 and 860
Non-monsoon	835 m < WL < 840 m	430 and 860

Table 4.1 – Criteria for setting spillway gate levels and turbines discharge at Baglihar[112]

3.11. Thus, India's own long-term sedimentation report for the Baglihar HEP confirmed that *seasonal sluicing is able to sustain the operating pool*, even when considering a 100-year simulation.

3.12. The DHI modelling was based on data available in 2005, when the Baglihar HEP was not operational. Based on the limited data that Pakistan has on the Baglihar HEP today, Pakistan presents an updated model of sedimentation at that site in **Annex II** hereof, based on the sediment used in the DHI report. This demonstrates that the capacity of the Operating Pool at Baglihar can be preserved with seasonal sluicing for over 100 years, out to year 2138, which is consistent with the results obtained by India's expert.

[112] *Id.*, section 4.5.2, p. 15.

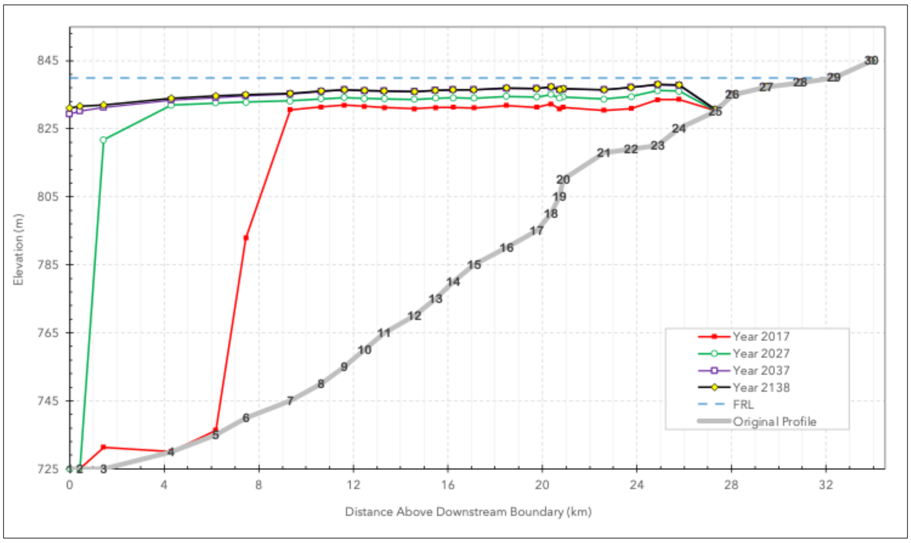

Figure 1 – Sedimentation Profiles for the Sluicing Scenario[113]

3.13. Seasonal sluicing would involve holding the reservoir at the Minimum Operating Level during the full flood season, meaning that the Operating Pool would be <u>above</u> the water surface when the most sediment enters the reservoir. Being empty, there would be little opportunity for sediment to accumulate in the Operating Pool. As Pakistan has previously explained, this is an environmentally friendly strategy that is focused on passing sediment-laden floods through the reservoir and into the downstream river according to the natural occurrence of floods, without creating excessive sediment concentrations in the river below the dam as occurs during drawdown for flushing.[114]

3.14. Pakistan recalls that paragraph 2.5 of PO14 notes the Court's interest in the "relevance of reservoir sediment accumulation with respect to the potential weaponization of HEPs on the Western Rivers." As Dr Morris explained during the Hearing, "weaponization" refers to Pakistan's three contemporary concerns regarding India's control over the waters of the Western Rivers: the interruption of water supply for irrigation; opening of the gates to create flooding downstream; and the rapid mass release of sediment impacting infrastructure downstream.[115] The third concern only becomes a potential threat when there is sediment accumulation in the reservoir combined with design features such as low-level outlets that enable its mass release downstream.

[113] Sedimentation profiles for the sluicing scenario, drawing the reservoir down to the dead storage level (DSL) during the wet season. Several meters of water depth (pondage) is retained in the reservoir even out to year 2138. *See further* **Annex II.**
[114] *COA* Memorial, ¶ 4.134.
[115] Transcript of Hearing for the First Phase on the Merits, 11 July 2024 (Day 4), p. 73, lines 1-6 (Dr Morris).

3.15. Turning to paragraph 2.6 of PO14, the Court notes that "Pakistan did not appear to contest such potential near-term effects of sediment accumulation on Pondage during the *Baglihar* Neutral Expert proceedings, nor did it address in this proceeding such effects for HEPs generally on the Western Rivers."

3.16. As Pakistan noted in its Preliminary Comments, the analysis advanced by both India and Pakistan during the *Baglihar* proceedings was based on the <u>assumption of sluicing</u>, not the use of drawdown flushing.[116] In the course of the Third *Baglihar* Meeting, India changed its position to state that it considered that the question of flushing did <u>not</u> arise with respect to the Baglihar HEP and that no further comment on this matter was required. Mr Shankardass, India's Counsel stated:

> Sir, I want to conclude by just one reference, that – this perhaps relates to 8(e) – and that is that on a number of occasions, we have heard people say that the Treaty does not allow flushing at all. I want to just place it on record that **that issue has not arisen in this case. Our design, we have repeatedly said, is intended to be worked with sluicing.** The issue of whether or not flushing is permitted by the Treaty is not something which we have either argued and that is something – in other words, that is something to be debated and argued and decided at some other point in time as to whether it is or it is not allowed; it does not arise in this case and does not need any comment, is my respectful submission.[117]

3.17. Between the Third and Fourth Meetings, however, for reasons that are not evident from the record, it appears that the Neutral Expert reached a conclusion that, notwithstanding the Parties' positions to the contrary, drawdown flushing was permitted under the Treaty.

3.18. In the Fourth Meeting of the *Baglihar* proceedings, when the Neutral Expert presented his draft final report, he announced that, in his view, flushing was part of the "state-of-the-art" with respect to sediment management and that the Treaty permitted it.[118] This position expressed by the Neutral Expert thereafter became the foundation of India's case going forward, and it proved impossible for Pakistan to reopen the issue for consideration by the

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[116] *Baglihar Hydroelectric Plant (Pakistan v India*), Indus Waters Treaty Annexure F, Neutral Expert Determination, **PLA-0002**, p. 56.

[117] On the basis that the Baglihar HEP had been designed to work with sluicing as the principal form of sediment management: Transcript of the Third Meeting of the Neutral Expert with the Parties, Day 3 (Master Corrected Transcript) (*Baglihar* Neutral Expert proceedings), 28 May 2006, **Exhibit P-0547/BR-0031**, pp. 138, line 22 – p. 139, line 7 (emphasis added). Pakistan's position remained that the Treaty prohibits flushing: *id*., p. 3, lines 14-16.

[118] Transcript of the Fourth Meeting of the Neutral Expert with the Parties, Day 3 (Master Corrected Transcript) (*Baglihar* Neutral Expert proceedings), Day 1, 2 October 2006, **Exhibit P-0547/BR-0034**, p. 51, line 8 – p. 82, line 7.

Neutral Expert.[119] As the Court well appreciates at this point, it is Pakistan's position that the Neutral Expert's Treaty analysis was both flawed and exceeded his competence – and was rejected, as a matter of systemic interpretation, by the *Kishenganga* Court.

3.19. In addition, Pakistan did not contest the potential near-term effects of sediment accumulation during the *Baglihar* Neutral Expert proceedings because Pakistan's main point was a different one. In Pakistan's view, the reservoir of the Baglihar HEP would fill as a function of the operational water level, which is independent of the elevation of the spillway gate. For its part, India claimed that the low-level gates would preserve a sediment-clear pool extending upstream beyond the power intake.[120]

3.20. Pakistan disagreed with India's position on this point because it considered that the pool was very localised and not affected by the gates.

3.21. The difference in operational levels between full pondage and the Dead Storage Level during the monsoon season would have no appreciable effect on Baglihar reservoir's sediment trapping efficiency. As Pakistan explained in the proceedings:

> Pakistan's mathematical model shows that the average trap efficiency in the first 20 years of operation of the Baglihar reservoir is 71 % at FPL of el. 840 m. In comparison, the trap efficiencies of the Baglihar Reservoir with the reservoir operating at el. 835 m is 70% as shown below … [T]he simple and very obvious fact to note here is that there is no significant difference between the trap efficiencies at DSL and FPL adopted by India.[121]

[119] Pakistan attempted to clarify the issue in its comments on the Neutral Expert's Draft Determination shared with the Parties during the Fourth Meeting (Final Draft Determination with Annexes 1, 4, 5 and 6, dated 2-3 October 2006, **Exhibit P-0547/BR-0043**). In its comments, Pakistan agreed with the Neutral Expert's preliminary observation in his draft determination that drawdown flushing was "proscribed" by the Treaty, and further objected to the use of flushing for reasons of preparing a "safe" dam design, or for the control of "far-field sediment" (Comments of Government of Pakistan on the Final Draft Determination by the Neutral Expert, **Exhibit P-0547/BR-0044**, pp. 6, 10-11, 15-19).

[120] Counter-Memorial of the Government of India (*Baglihar* Neutral Expert proceedings), **Exhibit P-0547/BR-0008**, section 1.7.1, p. 40.

[121] Reply of the Government of Pakistan to the Counter Memorial by Government of India (*Baglihar* Neutral Expert proceedings), **Exhibit P-0547/BR-0010**, section 2.14, p. 50.

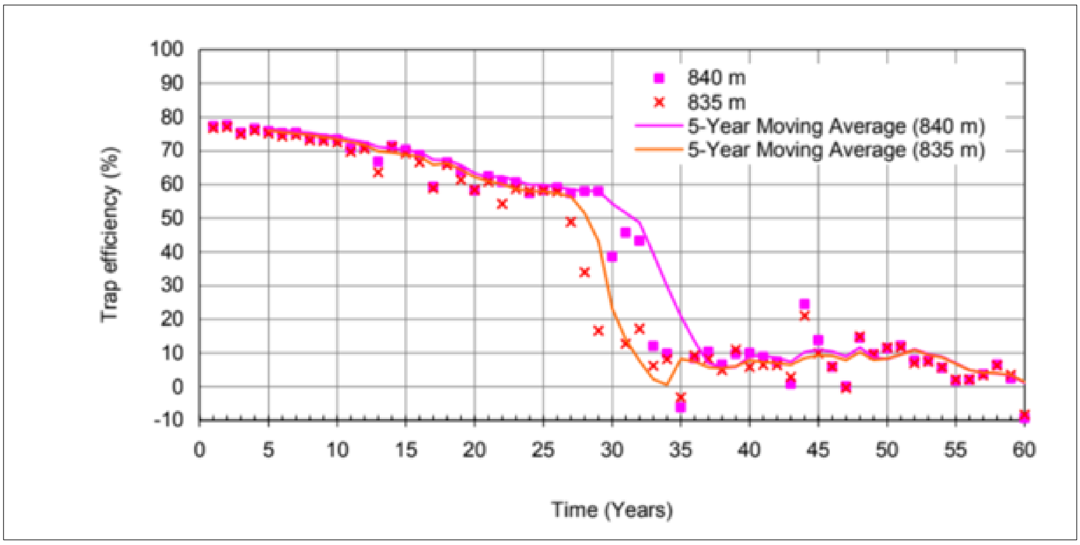

Figure 2 – Baglihar Reservoir Sediment Trapping Efficiency Comparison at Different Full Pondage Levels[122]

3.22. As foreshadowed in its Preliminary Comments, Pakistan notes that both of the models used by India in the *Baglihar* proceedings had significant limitations. Two different models were prepared by DHI.[123] In one of them, India used an "assumed" particle size distribution in which all sediments ranged from sand (>0.062 mm) to gravel (>2 mm). No silt or clay was simulated to exist in the river, and for that reason the model simulated the growth of a delta with a very steep foreslope. This model showed sediment reaching the low-level outlet sill in only twelve years. In the second model, DHI used a d50 = 0.22 mm grain size to represent all sediment, which model showed sediment reaching the sill of the low-level outlets after about 30 years. In both models, DHI ignored the presence of silt and clay, which comprise over half the sediment in the Chenab.[124] India did not provide data on the particle size distribution of the suspended sediment, nor were the models calibrated against the sedimentation history of the Salal HEP. In the second DHI model, a 3-dimensional model, there was also an error in India's boundary conditions for the near field zone. The linkage of the 3-dimensional and 1-dimensional models created a situation where an arbitrarily selected bed profile to the intake was defined and then reproduced in the models. This particular error was noted in the Neutral Expert's Final Determination in respect of sediment concentration at the power intake:

[122] *Id.*, section 2.14, p. 53.
[123] DHI, 'Baglihar Sedimentation Study' (*Baglihar* Neutral Expert Proceedings), **Exhibit P-0547/BR-0021**.
[124] S.V.N. Rao, et al. (1997) "A Study of Sedimentation in Chenab Basin in Western Himalayas." *Nord. Hydrol.*, 28 (3): 201–216, **Exhibit P-0663**.

> These calculations are correct, but it appears to the NE that the hypothesis of a geometry of the model which largely clears the water intakes from bed load sediments at a distance of 300 m from the dam, does not correspond to the physical reality.[125]

3.23. Paragraph 2.7 of PO14 invited the Parties to comment on the relevance of the near-term effects of sediment accumulation when interpreting the Treaty's provisions on the calculation of Pondage. As Pakistan noted in its Preliminary Comments, Pondage cannot be preserved by simply making the reservoir larger. Even the excessively large Operating Pools at Indian HEPs can be filled with sediment if India operates these facilities by continuously sustaining a high pool level, an operational procedure that maximises sedimentation.

3.24. Further, as noted in the response to paragraph 2.5 of PO14, actions to preserve Pondage against sedimentation requires that the reservoir be operated in a manner that complies with the limitations imposed by the Treaty. This can be achieved by seasonal sluicing, namely, by holding the reservoir at the minimum allowable level (the Dead Storage Level) during the wet season to prevent sediment accumulation within the Pondage pool. Other Treaty-compliant options, such as dredging, could also be used.

3.25. Finally, Pakistan recalls that the utilisation of Pondage under the Treaty is tied to power production, not to sediment management – as is clear in the Treaty itself and as explained by Pakistan at the Hearing by reference to the text of Paragraph 2(c) of Annexure D.[126]

IV. THE COURT'S QUESTIONS ON WIDER RESEARCH

4.1. In paragraph 2.8 of PO14, the Court references two articles in the public domain that address the actual or estimated sedimentation accumulation rates of reservoirs on the Western Rivers, including the Baglihar HEP, and the resulting loss in the volume of Pondage and controllable storage. In paragraph 2.9 of PO14, the Court invites comments on the available data (including in the public domain) addressing these matters.

4.2. To assist the Court, Pakistan has undertaken a review of recent literature to address key aspects of reservoir sedimentation and its management on the Western Rivers. The review focuses on peer-reviewed articles and theses or dissertations that have been subject to

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[125] *Baglihar Hydro-electric Plant (Pakistan v India)*, Neutral Expert Determination on the Baglihar Hydro-electric Plant dated 12 February 2007, **PLA-0002**, p. 54.

[126] Transcript of Hearing for the First Phase on the Merits, 16 July 2024 (Day 7), p. 60, line 20 – p. 61, line 7 (Dr Miles).

University examination. The observations are set out at **Annex III** to these Comments.

4.3. Several insights arise from the literature review:

(a) One of the challenges with sediment management in the Himalaya is the high sediment load and the variability of sediment yields. Nonetheless, there are general guidelines for management that require accurate long-term sediment monitoring and modelling and the use of seasonal sluicing to reduce the filling of live storage capacity.

(b) Reservoir sedimentation rates are best measured by reference to the amount of sediment that becomes trapped in reservoirs because reservoirs capture sediment from every runoff event from the date they begin impounding water. By contrast, gauge records may be missing reliable data from the largest sediment-producing events due to measurement difficulties during extreme floods or due to lapses in the gauge record.

(c) The Indus Basin is distinctive as an estimated 66% of the Indus discharge is contributed by snowmelt, which is the highest snowmelt contribution across the entire Himalayan zone.

(d) Insights on sediment management may be gained from studies and practices in the Indus Basin, including how the reservoirs interact with each other and the lack of viability of drawdown flushing as compared to a more measured release schedule.

(e) The efficiency of sluicing, as demonstrated by modelling of sedimentation at Baglihar by India's expert, has been confirmed by an updated simulation (*see* **Annex II**).

4.4. As regards the two articles mentioned in paragraph 2.8 of PO14, Pakistan makes the following observations (developed in further detail in **Annex III**):

(a) Kumar, et al., 'Sediment Budget and Sediment Trap efficiency of Baglihar Hydroelectric project Reservoir – a calibrated model for prediction of longevity of the Dam' (2021) 38(1) *Journal of The Indian Association of Sedimentologists*

65[127]: this article is unreliable and produces unrealistic results.

i. **First**, although the article states calibration was performed, no information on calibration data or methodology is presented.

ii. **Second**, calculation of the rate of storage loss without sediment management, showing only a 40% loss in 100 years, is unrealistically low and is contradicted by all other studies at this reservoir, including the analysis conducted by Pakistan in **Annex II** below.

iii. **Third**, the article's flushing analysis is unreliable and unclear as to the type of flushing scheme or the calculation of its effectiveness.

iv. **Fourth**, there are basic errors in the plotting of minimum, maximum and average values in the 10-day flows over time.

(b) Muhammad Nouman, 'Analysis of Silt Transport, Deposition and Its Management in the Reservoirs Built on Run-off the Rivers Case Study: Modelling of Silt Flushing through Sluice Gate in Baglihar Hydroelectric Generation Plant, India' (Thesis, 2020)[128]: this appears to be very similar to a 2015 Masters' thesis by Muhammad Irfan.[129] Pakistan conducted an analysis of Mr Irfan's thesis (obtained from the IHE Delft) in **Annex III**. There are no obvious problems with the underlying data of the thesis, nor the overall conclusion that the useful life of the Baglihar reservoir will be about 50 – 60 years, absent sediment management. However, this study analysed hypothetical conditions, not the reservoir's actual physical configuration and operational procedures.

4.5. In addition to the two articles referenced by the Court, Pakistan's literature review

[127] R.A. Kumar, et al. (2021). "Sediment Budget and Sediment Trap efficiency of Baglihar Hydroelectric project Reservoir – a calibrated model for prediction of longevity of the Dam." *J. Indian Assoc. Sedimentol.*, 38 (1), **Exhibit P-0664**.

[128] M. Nouman. (2020) "Analysis of Silt Transport, Deposition and Its Management in the Reservoirs Built on Run-off the Rivers Case Study: Modelling of Silt Flushing through Sluice Gate in Baglihar Hydroelectric Generation Plant, India" (Thesis), **Exhibit P-0665**.

[129] M. Irfan. (2015). "Sediment Management in Reservoirs Built on Run-of-rivers : [case study : Modelling of Silt Sluicing Through Under Sluice Spillways in Baglihar Hydropower Dam, India]." M.S. Thesis. Delft, Netherlands: IHE Delft, **Exhibit P-0666**.

addresses twenty-eight other recent articles and studies in this area. As emerges from this review, seasonal sluicing is a viable method for sustaining the capacity of Run-of-River HEPs in the Himalayas. It is a robust sediment management technique that can sustain Pondage capacity.

*   *   *

ANNEX I – COMPARISON BETWEEN THE 1959 HEADS OF AGREEMENT AND THE TREATY AS CONCLUDED

1959 Heads of Agreement	1960 Treaty
DEFINITION **Paragraph 2** A "Run-of-River" Plant is a hydro-electric plant at which power is developed without live storage as an integral part of the plant, except for the storage in the operating pool, that is to say, the pondage required to meet fluctuations in the discharge of the turbines arising from the daily and weekly load of the power plant.	**Part I—Definitions** **Paragraph 2** As used in this Annexure: […] (c) "Pondage" means Live Storage of only sufficient magnitude to meet fluctuations in the discharge of the turbines arising from fluctuations in the daily and weekly loads of the plant. […] (g) "Run-of-River Plant" means a hydro-electric plant that develops power without Live Storage as an integral part of the plant, except for Pondage and Surcharge Storage. […] (i) "Firm Power" means the hydro-electric power corresponding to the minimum mean discharge at the site of a plant, the minimum mean discharge being calculated as follows: The average discharge for each 10-day period (1st to 10th, 11th to 20th and 21st to the end of the month) will be worked out for each year in which discharge data, whether observed or estimated, are proposed to be studied for the purpose of

	design. The mean of the yearly values for each 10-day period will then be worked out. The lowest of the mean values thus obtained will be taken as the minimum mean discharge. The studies will be based on data for as long a period as available but may be limited to the latest 5 years in the case of Small Plants (as defined in Paragraph 18) and to the latest 25 years in the case of other Plants (as defined in Paragraph 8). […]
DESIGN **Paragraph 3** Except as provided in paragraph 14 below, the design of any "Run-of-River" plant shall conform to the following criteria: […] b. The volume between the maximum and minimum levels of the operating pool shall not exceed that required to meet the daily or weekly load fluctuations as the case may require. […]	**Part 3—New run-of-river plants** **Paragraph 8** Except as provided in Paragraph 18, the design of any new Run-of-River Plant (hereinafter in this Part referred to as a Plant) shall conform to the following criteria: […] (c) The maximum Pondage in the Operating Pool shall not exceed twice the Pondage required for Firm Power. […]
SMALL PLANTS **Paragraph 14** Subject to the provisions of paragraph 18 below, the provisions of paragraphs 3, 4, 5, 6, and 7 above shall not apply to a run-of-river hydro-electric plant which conforms to the following criteria: a. it is not located on the main stem of any of the three Western	**Part 3—New run-of-river plants** […] **Paragraph 18** The provisions of Paragraphs 8, 9, 10, 11, 12 and 13 shall not apply to a Run-of-River Plant which is located on a Tributary and which confirms to the following criteria (hereinafter referred to as a Small Plant): (a) the aggregate maximum designed discharge through the

Rivers; b. no storage is involved in connection with the plant, except the forebay pondage required for daily and weekly load fluctuations and the storage incidental to the diversion structure; c. the crest of the diversion structure across the tributary, or the top level of the gates, if any, shall not be higher than 20 feet above the main bed of the tributary at the site of the structure; d. the aggregate maximum designed discharge through the turbines does not exceed 300 cusecs.	turbines does not exceed 300 cusecs; (b) no storage is involved in connection with the Small Plant, except the Pondage and the storage incidental to the diversion structure; and (c) the crest of the diversion structure across a Tributary, or the top level of the gates, if any, shall not be higher than 20 feet above the mean bed of the Tributary at the site of the structure.

* * *

ANNEX II – INDEPENDENT SIMULATION OF BAGLIHAR SEDIMENTATION

II.1. Pakistan, through Dr Morris, has performed an independent simulation of sedimentation at Baglihar. The first exercise was to simulate the rate of sedimentation for conditions with the reservoir held continuously at a maximum level of 840 m, without either sluicing or flushing. The second exercise modified the model to simulate sediment sluicing by holding the water level at 836 m during the monsoon.

A. SLUICING VS. FLUSHING OVERVIEW

II.2. Sedimentation in the reservoir can be undertaken by two alternative strategies: flushing or sluicing. The difference is the degree of drawdown and, indirectly, the placement of spillways.

(a) **Flushing**. For reservoir flushing, deep outlets are used to draw down the reservoir below the minimum drawdown level ("**MDDL**"), which corresponds to the Dead Storage Level ("**DSL**") for Annexure D dams. The reservoir may be held at this "empty" level for several days, or even weeks, to allow river inflow to scour accumulated sediment and release it downstream. Under this operating rule the reservoir will be drawn down below DSL, held at the low-level for as long as necessary, and then refilled by closing the gates, allowing some release during the refill period to sustain a minimum flow in the river. The rate of drawdown will be dictated by the maximum allowable sediment concentration released from the dam. The peak concentration of a flushing release could easily surpass 200,000 mg/l if the Baglihar HEP reservoir were allowed to dewater rapidly. This is an extreme sediment concentration which would kill all the fish in the river and also preclude any type of withdrawal for water supply or irrigation.

By maintaining a large reservoir capacity by flushing operation, the reservoir can serve as a highly efficient sediment trap between flushing events. Although this has the advantage of protecting the turbines, it has the very real disadvantage of maximising the amount of sediment captured in the reservoir and which must then be discharged during the flushing event. To achieve a sediment balance, the entire annual sediment load trapped in the reservoir must be discharged over the course of the flushing event. Because of the high sediment concentration, power production would also need to be halted at the downstream Salal HEP as well to protect the turbines there, since turbines should typically not be operated when the concentration exceeds a pre-determined limit, of 3,500 parts per million ("ppm") (Joshi et al, 2021).[130] Flushing is prohibited by many governments due to the deleterious impacts to both river ecology and downstream users.

(b) **Sluicing**. For seasonal sluicing operation the reservoir level is drawn down to the MDDL. By sustaining the water level within the Plant's operational range, the turbines can continue operating during the wet season, when they would normally be operating at full power. This practice was specifically recommended for Himalayan reservoirs by Joshi et al. (2020):

> It is international practice to maintain the reservoir at low level during monsoon so that majority of incoming sediment is passed in the downstream through the spillway. During sluicing, reservoir is maintained at lower levels (normally near MDDL), which decreases the effective capacity of the reservoir.[131]

II.3. By using sluicing to keep the Operating Pool empty during the monsoon, the potential for sediment accumulation with the Pondage is largely eliminated, and at the same time the HEP continues to operate at full power except on those days with high concentration as mentioned previously. This allows for the continuous discharge of sediment downstream instead of discharging an entire year of sediment accumulation downstream in the space of one or several weeks as occurs with flushing. This avoids the adverse downstream consequences of massive sediment release in addition to avoiding the loss of power production at both the flushing site and at any downstream site(s).

II.4. As a trade-off, sluicing increases the sediment load on the turbines as compared to flushing because the reservoir is not trapping sediment during the wet season. This calls for responses such as provision of a skimming facility (such as the "silt exclusion basin" described at the Kol plant on the Chenab River in the accompanying literature review), desilting basins (as at the NJHEP that was visited in Pakistan), the use of abrasion-resistant coatings, and more frequent repair of turbine runners and guide vanes. Nevertheless, these options can be

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[130] B. Joshi et al. (2021). "Sediment Management Practices in NHPC's Power Stations." *ICOLD 2021 Workshop Sediment Manag. Reserv. Sustain. Dev,* **Exhibit P-0662**.

[131] B. Joshi, et al. (2020). "Sediment Management Practices at NHPC's Power Stations." *Hydropower Dams* 27(2), **Exhibit P-0667**, p. 31.

economically attractive as compared to the power loss and downstream impacts associated with flushing.

B. MODELLING DESCRIPTION

II.5. The Treaty prohibits drawdown below DSL (MDDL) for the purpose of sediment flushing. In contrast, sluicing is an allowable sediment management procedure as it does not draw down the reservoir below DSL. Pakistan has asserted that sluicing can be effective as a long-term sediment management strategy in Himalayan run-of-river reservoirs operating under Treaty restrictions. Given the high cost of flushing, sluicing may even be the more economical alternative, but the analysis of sluicing provided below is limited to technical feasibility only.

II.6. Modelling was performed using the SRH-1D sediment transport model developed by the US Bureau of Reclamation.[132] This model has been used on numerous reservoirs in the Caribbean, Andes, and Himalaya, including a just-completed study of the fully sedimented Warsak run-of-river HEP reservoir on the Kabul River in Pakistan where the model was calibrated using field data from two reservoir drawdown events.

II.7. The flow data used in the Baglihar model were as provided to Pakistan by India for the gauge station at Premnagar under Article VI(1)(a) of the Treaty, with missing data infilled, as provided by National Engineering Services Pakistan ("**NESPAK**"). The available flow time series was repeated three times to produce a 132-year simulation duration. Sediment characteristics, including the suspended sediment rating relationship, were based on the material provided by India in the course of the *Baglihar* Neutral Expert proceedings. The initial (pre-impoundment) geometry was obtained from NESPAK.

II.8. The configuration of the Baglihar HEP, including the location of outlets and operating levels, are as described by India in their design notifications required by the Treaty, as modified by the Neutral Expert. The following scenarios were simulated:

[132] B. Greimann. and J. V. Huang, *User's Manual for SRH-1D V4.0: Sedimentation and River Hydraulics – One Dimension*, (Version 4.0: Denver, CO: U.S. Bureau of Reclamation 2018), **Exhibit P-0668**.

1) **Baseline**. Under the first scenario, the baseline scenario, the reservoir is continuously held at Full Reservoir Level ("**FRL**") of 840 m and there is no sediment management.

2) **Sluicing**. Under the second scenario, sluicing is undertaken by seasonally lowering the reservoir level to DSL of 836 m between 15 June and 15 September of each year.

II.9. The typical pattern of daily discharge and sluicing is provided in **Figure II.1** which graphs both river discharge and water level in the reservoir for two years, clearly showing the period when drawdown sluicing occurs. Under this operational rule drawdown for sluicing begins on 15 June and ends on 15 September, but sluicing could also be scheduled based on inflow rate instead of being set by calendar dates.

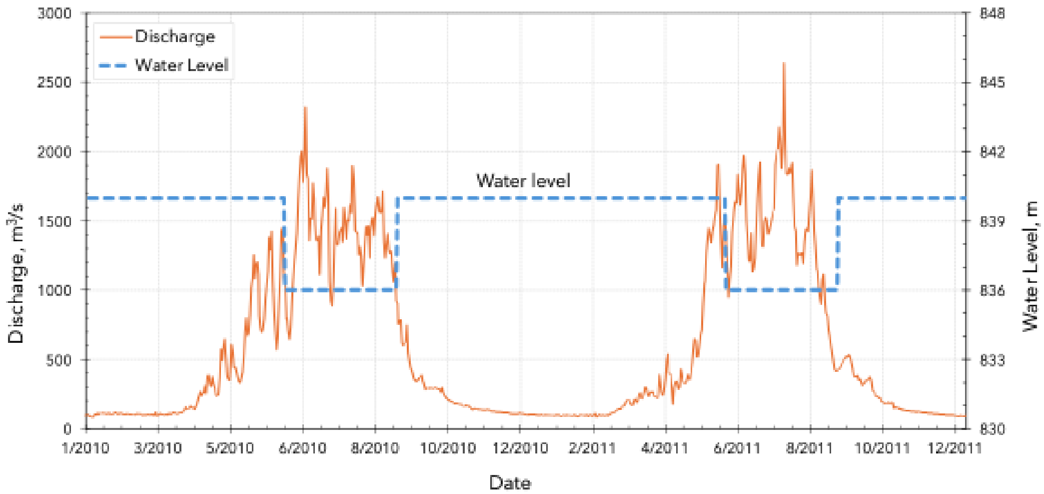

Figure II.1- Discharge Data for Years 2010 and 2011 Showing Periods of Normal Operation and the Periods of Reservoir Drawdown for Sluicing.

C. Simulation Results

II.10. The results of the simulations are illustrated in the longitudinal profiles provided below. These profiles are section views along the length of the reservoir, with the dam on the left and the direction of flow in the graphic from right-to-left. The original (pre-impoundment) river profile is shown as a heavy grey line, with thinner lines showing the extent of sediment advance into the reservoir for different years.

II.11. The first simulation scenario (**Figure II.2**) is the "baseline" case; the reservoir is continuously held at a high level. Under this scenario the reservoir loses a major part of the

Pondage capacity and sediment fills virtually the entire reservoir after about 30 years. This closely matches the results given by India's analysis by DHI and presented at the *Baglihar* Neutral Expert proceedings,[133] which is cited in the accompanying literature review.

II.12. The second scenario (**Figure II.3**) shows the pattern of sediment advance for seasonal sluicing between 15 June and 15 September, as previously described. Under this scenario the capacity of the operational pool is preserved even out to year 2138. This result is also very similar to that previously shown by India's sedimentation analysis in **Figure 4.11** from the DHI study.[134] That analysis presented a long term (100-year) simulation of sluicing in the Baglihar reservoir showing stabilisation of the sediment profile while preserving Pondage.

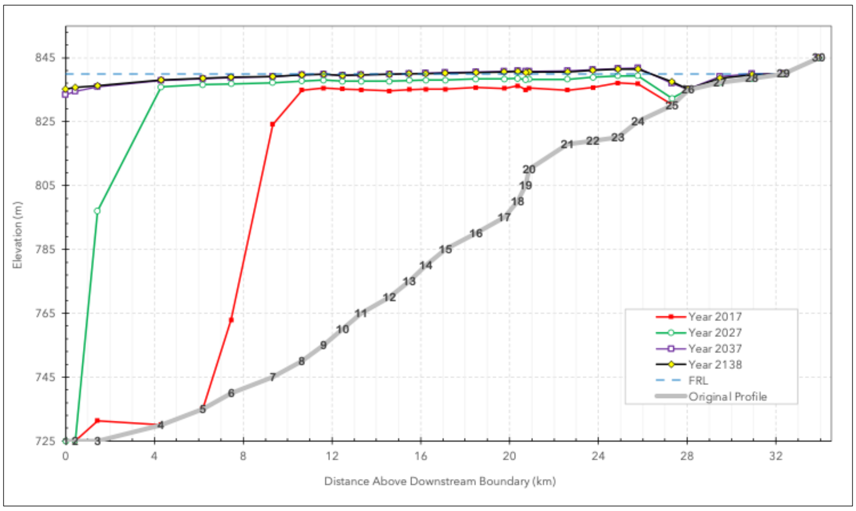

Figure II.2 - Sedimentation profiles for the baseline condition, holding the reservoir continuously at a high level (840 m), showing that sedimentation fills dead storage plus most of the operational pool.

[133] DHI, 'Baglihar Sedimentation Study' (*Baglihar* Neutral Expert Proceedings), **Exhibit P-0547/BR-0021**.
[134] *Id.*, p. 29.

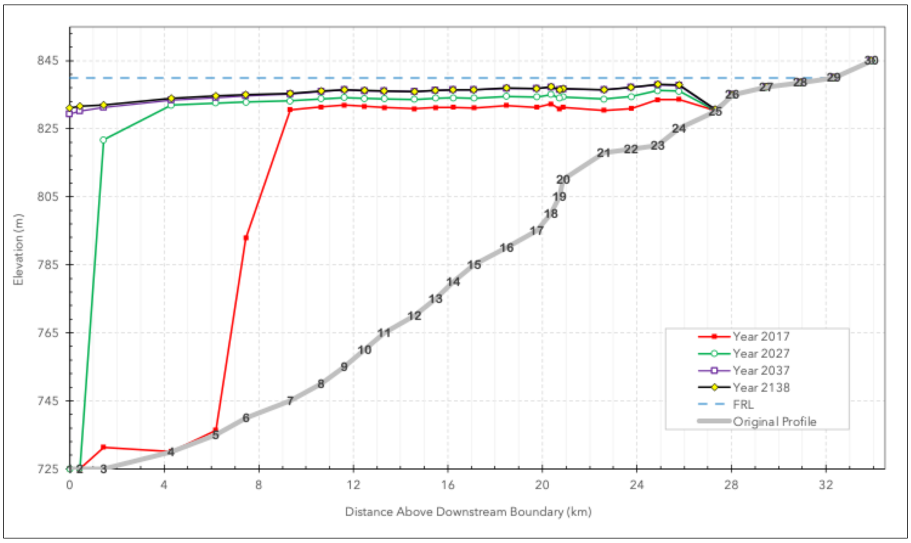

Figure II.3 - Sedimentation profiles for the sluicing scenario, drawing the reservoir down to the Dead Storage Level (DSL) during the wet season. Several meters of water depth (Pondage) is Dead Storage Level retained in the reservoir even out to year 2138.

D. CONCLUSIONS RELATED TO SLUICING

II.13. The modelling performed illustrates the viability of using sluicing to sustain the capacity of a run-of-river operational pool (Pondage) in the Himalaya, arriving at technical feasibility conclusions consistent with the results of the other modelling studies at Baglihar previously conducted by others (*see also* **Annex III** below).

* * *

ANNEX III – OBSERVATIONS ON AVAILABLE DATA REGARDING THE ACTUAL OR ESTIMATED SEDIMENTATION ACCUMULATION RATES OF RESERVOIRS ON THE WESTERN RIVERS

III.1 In these Observations, Pakistan, through Dr Morris, considers the most relevant public domain literature on key aspects of reservoir sedimentation and its management on Western Rivers subject to the Treaty. Using the technique of a literature review, Dr Morris has focused on peer-reviewed articles and theses or dissertations that have been subject to University examination. The review addresses recent and up-to-date references, and does not cite older documents which provide information or analysis that has been superseded. In undertaking this review, errors and inconsistencies in the literature have also been pointed out.

III.2 This review of the literature is organised as follows:

I. Sediment Management Options

II. Reservoir Sedimentation Rates

III. Source of Runoff

IV. Studies on The Indus Main

V. Mangla Reservoir on The Jhelum

VI. Studies in The Chenab River

VII. References

III.3 In preparing these Observations, it should be noted that not all of the reservoirs cited fall under the purview of Annexure D of the Treaty, including all of the Pakistani reservoirs on the Western Rivers. The distinction between Treaty and non-Treaty reservoirs is mentioned in each case, which is important as, whereas drawdown below the Dead Storage Level for sediment flushing is allowed in non-Treaty reservoirs, it is specifically prohibited as a sediment management option at Treaty sites. These non-Treaty reservoirs within the Indus basin have been included because they help shed light on hydrologic conditions and management strategies within the basin.

I. SEDIMENT MANAGEMENT OPTIONS

A. SEDIMENT DATA UNCERTAINTY

III.4 One of the challenges in the Himalaya is the high sediment loads, data uncertainty and the variability of sediment yields. Within the Chenab, for example, sediment yields vary along the length of the river and correlate primarily on rainfall, as noted by Rao et al. (1997):

> The upper reaches of the Chenab basin have high slopes (or relief ratio) but the sediment yield per unit area is low, hence the negative correlation between sediment yield and slope. Similarly there is poor and negative correlation between % of vegetal cover and sediment yield. In other words the sediment yield response to relief ratio, slope or vegetal cover in the upper reaches of Himalayan catchments is the converse of what is normally expected in rainfed catchments in the rest of India. The reason could be attributed to geological land cover conditions in the upper reaches (roughly beyond 3,000m corresponding to the treeline) with diminishing soil cover. Rainfall showed positive correlation with sediment yield and enters most of the regression equations.[135]

III.5 There are also sampling problems. First, there is the impossibility of measuring bed load from steep, high-discharge Himalayan rivers with large bed material (cobbles and boulders). Second, as a result bed loads are assumed values rather than measured values with respect to suspended sediment. Sen and Shankracharya (1992) made the following notes concerning suspended sediment sampling procedures at gauge stations along the Chenab:

> Punjab type bottle samplers are used for silt observation. The sample thus collected are analysed for three ranges: fine (less than 0.075 mm), medium (0.075 – 0.2 mm), and coarse (>0.2 mm). In order to account for lower trapping efficiency of the bottle sampler, a correction factor of 1.43 is applied to coarse and medium silt.[136]

III.6 Application of a correction factor of 1.43 under all discharge conditions suggests that there is significant potential for error in the sampled concentration.

B. GENERAL GUIDELINES FOR HIMALAYAN SEDIMENT MANAGEMENT

III.7 Sediment management experience at 20 hydropower stations in the Himalayan region operated by India’s NHPC Ltd (formerly known as the National Hydroelectric Power

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[135] S.V.N. Rao, et al. (1997) “A Study of Sedimentation in Chenab Basin in Western Himalayas.” *Nord. Hydrol.*, 28 (3): 201–216, **Exhibit P-0663**, p. 213.
[136] S.P. Sen and Shankracharya. (1992). “Sedimentation Study of Reservoir for Baglihar HE Project.” *Intl Symp Hydrol. Mt. Areas*, 259–271. Shimla, India, **Exhibit P-0669**, p. 261.

Corporation) has been summarised by Joshi et al. (2020).[137] The recommended practices are:

- Prepare project-specific sediment management guidelines;
- Perform accurate long-term sediment monitoring at gauge stations and regular bathymetric surveys using fixed transect lines;
- To reduce filling of live storage capacity, operate reservoirs at/near MDDL [Minimum Draw Down Level] during high flow periods to sluice sediments, and conduct periodic free flow flushing in run-of-river schemes with small storage capacities;
- Place the intake level sufficiently above the spillway crest to reduce sediment entry,
- Make arrangements to exclude large sediment (usually 0.2 mm) from water delivered to turbines;
- Simulate long-term reservoir sedimentation using mathematical modelling, extending the modelling period until a stable longitudinal profile and sediment balance across the dam has been achieved;
- Conduct physical model studies for each project to test hydraulics and sediment management schemes; and
- Coordinate and synchronise sediment management operations for projects in cascade.

III.8 Additionally, at each plant it is typical to specify a maximum value of either inflow or of suspended sediment concentration which will trigger shutdown of the power plant and transition to flushing operation.

III.9 The stated consequences of failing to properly manage sediment is increased maintenance costs:

[137] B. Joshi, et al. (2020). "Sediment Management Practices at NHPC's Power Stations." *Hydropower Dams* 27(2), **Exhibit P-0667**, p. 34

> It has been observed that if appropriate reservoir operation and flushing guidelines are not adhered to, along with significant loss in reservoir capacity, the runner and guidevanes will need to be repaired every year. However, if guidelines as proposed in the manuals are followed, the repair cycle for runner and guidevanes has increased to 2-3 years and 3-4 years respectively.[138]

III.10 In summary, improved operational efficiencies and reduced costs can be achieved with enhanced sediment management, while recognising that projects can be operated without implementing optimised sediment management techniques.

C. KOL DAM SILT EXCLUSION CHAMBER

III.11 The article by Kumar and Singh (2022)[139] discusses conditions in projects on both Western and Eastern Rivers as defined by the Treaty. It provides an interesting example case study of the sediment management strategy at the Kol dam (800 MW, 140 m head) which entered service in 2015 on the Sutlej – one of the Eastern Rivers. The Kol HEP has no low-level outlet and the spillway crest elevation of 625 m is 19 m above the power intake level of 606 m. The operating pool lies between FRL = 642 m and MDDL = 636 m. The objective is to deliver water to the turbines free of sediment particles coarser than 0.25 mm.

III.12 Kumar and Singh describe the "innovative scheme of silt exclusion" at the Kol Dam HEP as follows:

> Since there is no low flushing outlet, the flushing of sediment can be feasible through spillway only. In order to utilize the reservoir storage available between El 606.0 m (intake level) and El 625.0 m (spillway crest) for silt accumulation, a special arrangement has been developed in the form of a silt exclusion chamber or decanting chamber.
>
> The silt exclusion chamber has been designed in the form of a series of submerged weirs, enclosing the power intakes. The weirs have been designed having crest at El 631.75. This allows the withdrawal of design discharge of 800 m^3/s at MDDL as well as FRL. The underlying concept for such a decanting chamber is that the sediment particles shall continue to deposit in the reservoir and the water from the top-most zone of reservoir, above the weir crest shall be drawn for power intakes, which are otherwise located at a much lower level. Since the water in the upper region of the reservoir is devoid of particles of undesirable size, the power water intakes draw desilted water, at the same time fulfilling the water seal corresponding to MDDL. The design of the submerged weirs ensures that the setting of the crest level is such that the particles of

[138] *Id.,* p. 35.
[139] V. Kumar, and A. K. Singh. (2022). "Sediment Management for Reservoir Based hydropower Projects." *Intl Conf Hydropower Dams Dev. Water Energy Secur. – Chang. Clim.* Rishikesh, India, **Exhibit P-0670**.

> size 0.25 mm(+) are excluded from water conductor system. In principle, all the particles above 0.25 mm size settle in the reservoir as the velocities prevailing in the reservoir are extremely low. At the same time, deposited silt can be flushed through spillway, once it reaches upto the spillway crest level of 625 m, which is 6.75 m below the withdrawal level i.e. the crest of submerged weirs. The water to be drawn into the power intakes and water conductor system is thus free from the silt particles coarser than 0.25 mm.
>
> The final design of silt exclusion chamber was evolved based on extensive hydraulic model studies.[140]

III.13 According to the authors, "[t]his has proven to be a technologically advanced solution apart from huge cost savings."[141]

III.14 This silt exclusion chamber is basically a skimming weir constructed with a semi-rectangular geometry, as seen in **Figure III.1**. This structure can also be seen on Google Earth at Lat. 31.3845ºN, Long. 76.8715 E. To better understand this structure, the configuration sketched in **Figure III.2** has been drawn based on the information provided in the paper.

Figure III.1 - Pictorial view of Kol Dam decanting chamber in operation (Fig. 6c of Kumar and Singh (2022) with text annotations added).[142]

[140] *Id.*, p. 5.
[141] *Id.*, p. 11.
[142] *Id.*, p.7.

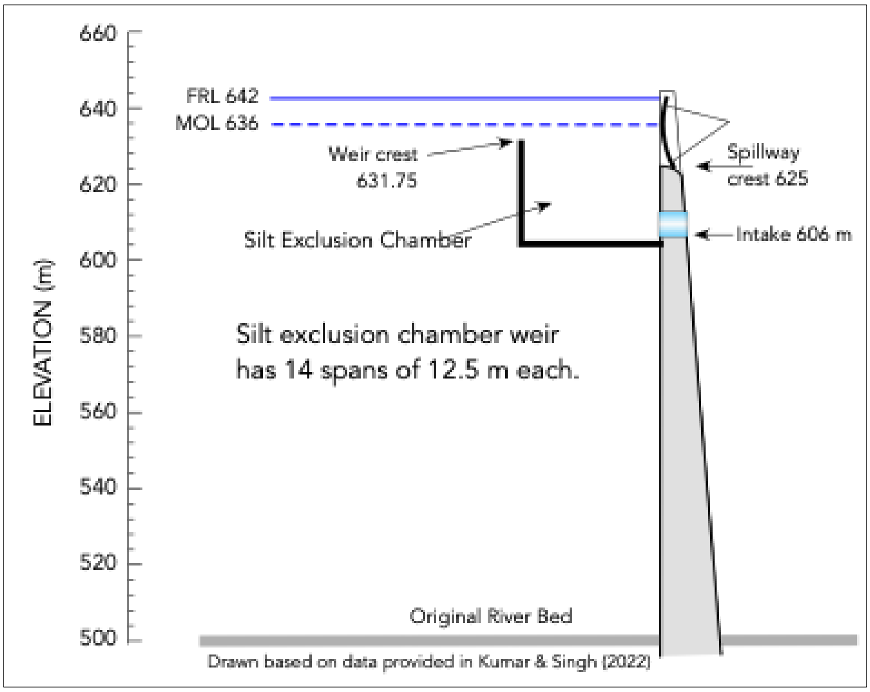

Figure III.2 - Schematic illustration of critical elevations related to the skimming arrangement for silt exclusion at the intake for the Kol HEP on the Sutlej River (drawn from data provided in Kumar and Singh (2022)).[143]

II. RESERVOIR SEDIMENTATION RATES

III.15 Sediment yield from catchment areas can be calculated from gauge station records, or it can be estimated from the amount of sediment that becomes trapped in reservoirs. This latter method is the most accurate because reservoirs capture sediment from every runoff event from the date they begin impounding water. In contrast, gauge records may be missing reliable data from the largest sediment-producing events due to measurement difficulties during extreme floods or due to lapses in the gauge record. Also, reservoir surveys provide a direct measurement of the volumetric rate of capacity loss, which is the parameter of our principal concern.

III.16 India's Central Water Commission (CWC, 2020) has published sedimentation data on 272 reservoirs throughout the country having hydrographic survey data, and sedimentation data from these reservoirs have been organised into seven regions.[144] These data are presented in **Table 6** of the CWC report, reproduced below, showing the sedimentation rate per unit of catchment area above the reservoirs. In other words, sedimentation rate has been normalised

[143] *Id.*, pp. 5-6.
[144] Central Water Commission. (2020). *Compendium on Sedimentation of Reservoirs in India*. New Delhi: Central Water Commission, **Exhibit P-0671**.

on a per square kilometer basis. To better visualise these data, the median values from Table 6 are graphed in **Figure III.3**. The "median" values have been plotted as the CWC document describes them, "to be more representative" as compared to the average value.[145] These data indicate that reservoir sedimentation rates in Himalayan reservoirs are not higher than rates being experienced elsewhere in India. In fact, the Himalayan region has the lowest median sedimentation reported for all regions. This may be attributed to a combination of high sediment yields due to soil degradation in many non-Himalayan areas throughout India, plus the implementation of measures to release sediment from certain Himalayan hydropower dams.

S.No	Number of Reservoirs	Region No.	Gross Storage (BCM)	Gross Storage Surveyed (BCM)	Loss In Gross Storage (BCM)	Annual Loss In Gross Storage (BCM)	% Loss in Gross Storage	% Annual Loss In Gross Storage	Avg. Observed Rate of Siltation (Th.CU.M/YR/Sq. KM)	Median (Th.CU.M/YR/Sq. KM)
1	34	1	27.15	22.88	4.27	4.05	32.7	3.58	1.22	0.41
2	15	2	28.95	24.98	3.97	6.29	21.2	0.46	0.95	0.72
3	5	3	17.23	14.15	3.08	17.76	11.66	0.36	0.76	0.68
4	118	4	69.15	57	12.15	3.08	19.25	0.61	2.33	0.44
5	53	5	6.4	5.28	1.12	0.76	19.36	0.82	1.12	0.86
6	10	6	10.15	8.88	1.27	4.09	18.63	0.86	2.84	0.65
7	37	7	11.63	10.78	0.85	0.73	15.27	0.41	3.07	2.07

Table 6 – Region Wise Analysis of 272 Reservoirs using Hydrographic Survey (Region names shown in Figure III.3)[146]

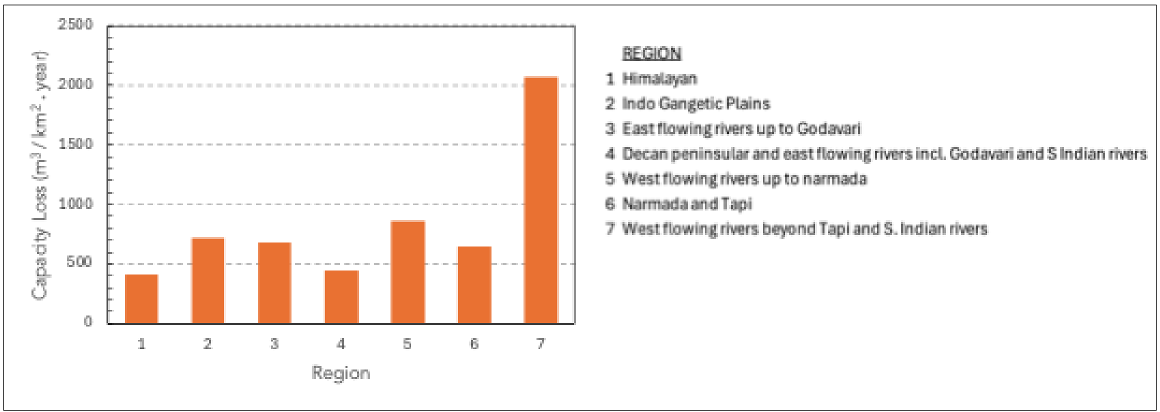

Figure III.3 - Rate of reservoir capacity loss per unit area of the tributary catchment (graphed from data in Table 6 above)

145 *Id.*, p. 14.
146 *Id.*.

III. SOURCE OF RUNOFF

III.17 An estimated 66% of the Indus discharge is contributed by snowmelt, which is the highest snowmelt contribution across the entire Himalayan zone, as seen below (Bookhagen and Burbank, 2010).[147] With respect to climate change, Krakauer et al. (2019) concluded that,

> Overall, our analysis of precipitation station observations and gridded data sets suggested a spatially and seasonally complex overall increasing trend for Indus basin precipitation.[148]

III.18 However, this will not necessarily increase river flow after accounting for higher temperatures and increased evaporation.

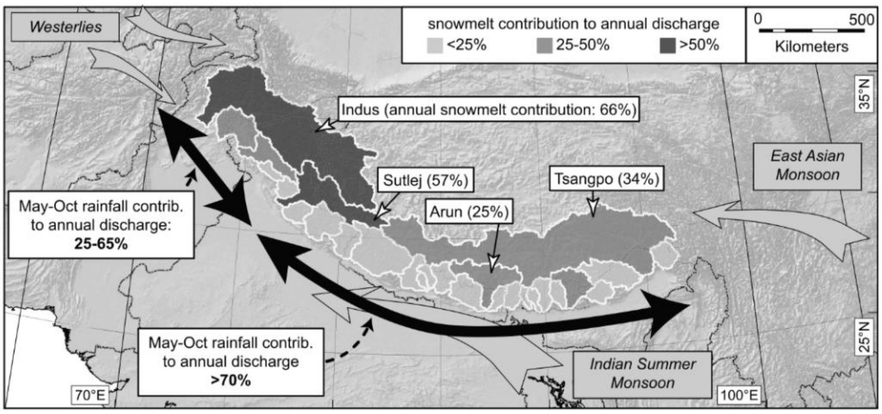

Figure 18. Conceptual climatic and hydrologic model for the Himalaya. Light gray shading of Himalayan catchments primarily in the central and eastern Himalaya indicate snowmelt contribution of <25% to annual discharge. Moderate to high snowmelt contribution occur in catchments with significant winter snow cover (e.g., Indus, Sutlej, Arun and Tsangpo). Black arrows indicate catchment and their corresponding summer (May to October) rainfall amounts: western catchments receive <65% of their annual discharge from rainfall (Indus: 40%), whereas catchments to the east of the Sutlej receive >70% of their annual discharge from rainfall. Gray arrows indicate major moisture-source directions.

Figure III.4 - Reproduction of Figure 18 from Bookhagen and Burbank (2010) showing snowmelt contribution to Himalayan runoff. [149]

[147] B. Bookhagen and D. W. Burbank. (2010). "Toward a complete Himalayan hydrological budget: Spatiotemporal distribution of snowmelt and rainfall and their impact on river discharge." *J. Geophys. Res. Earth Surf.*, 115 (F3): 2009JF001426, **Exhibit P-0672**, p. 22.
[148] N.Y. Krakauer, et al. (2019). "Precipitation Trends over the Indus Basin." *Climate* 7(10):116, **Exhibit P-0673**, p. 14.
[149] B. Bookhagen and D. W. Burbank. (2010). "Toward a complete Himalayan hydrological budget: Spatiotemporal distribution of snowmelt and rainfall and their impact on river discharge." *J. Geophys. Res. Earth Surf.*, 115 (F3): 2009JF001426, **Exhibit P-0672**, p. 30.

IV. STUDIES ON THE INDUS MAIN

D. OVERVIEW

III.19 The Indus Main has three reservoirs, all in Pakistan: the large Tarbela reservoir, which was first filled in 1975, plus the Dasu and Diamer-Basha reservoirs upstream of Tarbela, which are currently under construction. **Table III.1** summarises basic information on these projects. For the purpose of comparison, the average Indus flow at the Besham Qila gauge above Tarbela is 73.7 billion cubic meters (Bm^3/yr), an average flow rate of 2336 m^3/s (Rafique et al. (2020)).[150] The two under-construction upstream reservoirs are both provided with Low-level Outlets ("**LLO"**) which will allow them to retain their long-term storage capacity by annual flushing. However, Tarbela has no LLOs to enable flushing and no other mechanism to release sediment downstream to maintain active storage capacity while achieving a sediment balance.

Project	Design Gross Capacity, Bm^3	2024 Gross Capacity, Bm^3	Hydropower Capacity (MW)
Tarbela	14.3	7.12	7658
Dasu	1.4	In construction	4320
Diamer-Basha	10.0	In construction	4500

Table III.1 - Summary Characteristics of Pakistan's Storage Reservoirs on Indus Main.[151]

E. TARBELA

III.20 Numerous studies have been conducted related to sedimentation at Tarbela. A long-term record of sediment and water inflow exists at the Besham Qila gauge station upstream of the reservoir. This station gauges for most of the sediment load from its watershed, with additional but much smaller contributions from the Baraandu and Siran Rivers downstream of Besham Qila (Mazhar et al, 2021).[152] The results of the most recent comprehensive "Sediment Management Study for Tarbela" have been summarised by Haq (2013).[153] Tarbela dam does not have LLOs or other flushing facilities to enable the release of sediment downstream. The

[150] A. Rafique et al. (2020). "Analysis of Operational Changes of Tarbela Reservoir to Improve the Water Supply, Hydropower Generation, and Flood Control Objectives." *Sustainability* 12(18): 7822, **Exhibit P-0674**, p. 4.
[151] Note: Tarbela hydropower capacity includes 5th extension (under construction) plus the 1450 MW Ghazi Barotha run-of-river project located immediately below Tarbela dam.
[152] N.A. Mazhar, et al. (2021). "Effects of climatic factors on the sedimentation trends of Tarbela Reservoir, Pakistan." *SN Appl. Sci.*, 3 (1): 122, **Exhibit P-0675**.
[153] I. ul Haq. (2013). "Sediment Management of Tarbela Reservoir." *Proc 72nd Annu. Sess. Pak. Eng. Congr.*, 19–41. Lahore, **Exhibit P-0676**.

Haq study analysed the option of constructing nine flushing tunnels, each 10 m in diameter to provide a total flushing capacity of 5000 m^3/s at a drawdown level between 400 and 410 m, with a 30-day flushing duration. It was concluded:

> The tunnelling conditions may be expected to be difficult based on both the geology and the experience from the Tarbela Construction. Likewise the intakes, which will require under water construction, will be difficult and this is reflected in the cost estimates of USD 3.1 Billion for 5,000 m^3/s flush capacity.
>
> The economic studies have shown that the proposed TDSFP with a capacity of either 5,000 m^3/s or 3,000 m^3/s is not economically as well as financially viable.[154]

III.21 Of course, today's construction costs would be substantially higher than the cost estimated 12 years ago.

III.22 To date, Pakistan's sediment management strategy, implemented by its Water and Power Development Authority ("**WAPDA**") has been focused on the following activities: (1) construction of the two upstream reservoirs which will delay sedimentation at Tarbela by up to 30 years by trapping sediment in their dead (non-operational) pools, (2) gradually increasing the Minimum Operating Level ("**MOL**") at Tarbela to focus delta sedimentation into the upstream portion of the reservoir, thereby retarding delta advance, and (3) reconstruction of power intakes to withdraw water from higher levels in the reservoir to minimise sediment entrainment into the intakes (Munir et al, 2022).[155] However, to date, no activity has been initiated to balance sediment inflows and outflows at Tarbela.

III.23 Considerable uncertainty exists with regard to future runoff volumes and sediment yield from the upper Indus watersheds due to climate change. A regression analysis by Mazhar et al. (2021) correlated sediment yield at Tarbela to reservoir inflows, showing them to vary concurrently.[156] Simulations by Rafique et al. (2020) identified reservoir operational modifications at Tarbela that, as compared to the existing baseline rule curve, could reduce the impacts of increasing hydrologic variability due to climate change. This would enhance the reliability and resilience, and decrease vulnerability, with respect to the multiple objectives of

[154] *Id*., pp. 25-27.
[155] M.M. Munir, et al. (2022). "Simulation-Optimization of Tarbela Reservoir Operation to Enhance Multiple Benefits and to Achieve Sustainable Development Goals." *Water*, 14 (16): 2512, **Exhibit P-0677**.
[156] N.A. Mazhar, et al. (2021). "Effects of climatic factors on the sedimentation trends of Tarbela Reservoir, Pakistan." *SN Appl. Sci.*, 3 (1): 122, **Exhibit P-0675**.

irrigation, hydropower and flood control.[157] This study showed the benefits of modifying operational rules to maximise water and power yield in response changing inflow hydrology and water demand schedules, as compared to a continuation of the current operational procedures.

F. DASU

III.24 Dasu is the smallest of Pakistan's Indus Main reservoirs with 1.41 Bm^3 gross capacity and 0.82 Bm^3 of operational capacity. It is 74 km downstream of the much larger Diamer-Basha storage reservoir and will operate in conjunction with the upstream project. A sedimentation analysis for the Dasu reservoir was reported by Rehman et al. (2015).[158] Absent flushing, Dasu will be rendered inoperable within 20 to 25 years. Flushing scenarios at this site have been analysed by 1D HEC-RAS modelling using a modelling period of only 40 years. Flushing was simulated to last for one month during June (the same duration as upstream at Diamer-Basha), but this analysis was focused on simulation conditions without the upstream project. It was concluded that flushing should not be delayed by more than 15 years. It was also concluded that the upstream (Diamer-Basha) reservoir was necessary for sustainable operation of the Dasu project.

III.25 **Commentary on Dasu**. The Dasu study did not evaluate conditions with the upstream project (Diamer-Basha) constructed and operational. It also did not extend the simulation period long enough to allow sediment inflow and outflow to become balanced. Thus, these results should be considered highly preliminary as they do not represent true long-term conditions. One of the advantages of having Diamer-Basha upstream is the ability to initially empty Dasu, and then release flows from Diamer-Basha into the now-empty Dasu reservoir at pre-programmed times, using these releases from upstream to help move sediment out of Dasu.

G. DIAMER-BASHA

III.26 The general configuration of Diamer-Basha dam is illustrated in **Figure III.5** showing the placement of the low-level outlets for flushing the storage reservoir. The analysis of sedimentation rate and flushing alternatives was reported by Waqas and Tingsanchali

[157] A. Rafique, et al. (2020). "Analysis of Operational Changes of Tarbela Reservoir to Improve the Water Supply, Hydropower Generation, and Flood Control Objectives". *Sustainability* 12(18):7822, **Exhibit P-0674**.
[158] S.A. Rehman, et al. (2015). "Application of a 1-D numerical model for sediment management in Dasu Hydropower Project." *Proc14th Intl Conf Environ. Sci. Technol.* Rhodes, Greece, **Exhibit P-0678**.

(2016).[159] They concluded that for normal operation, without sediment management, the reservoir would lose about 80% of its capacity in 70 years. Four sediment management options were tested, with flushing scheduled at two different points in time. Under the normal (no flushing) operating rule, the reservoir is drawn down during the dry season for irrigation and power delivery, but not emptied for flushing. **Figure III.6** compares water levels for the normal operating rule and for the two flushing periods that were tested. Modelling was used to test empty flushing at intervals of 1-, 5- and 10-years. Four alternatives were tested and the resulting sediment management effectiveness are compared in **Table III.2.** In that table the following nomenclature of Atkinson (1996) has been used:[160]

(a) **SBR** - Sediment Balance Ratio refers to the ratio of sediment inflow to sediment discharge, and may be conceptualized as the efficiency of discharging sediment, defined as:

$$SBR = \frac{Sediment\ Entering\ the\ Reservoir}{Sediment\ Discharged\ from\ the\ Reservoir}$$

(b) **LTCR** - Long Term Capacity Ratio refers to the ratio of the sustainable capacity compared to the original capacity, defined as:

$$LTCR = \frac{Sustainable\ Capacity}{Original\ Capacity}$$

III.27 As seen in the table, the highest level of storage preservation (SBR = 0.96, LTCR = 0.48) was achieved when flushing was conducted on an annual basis and using the highest available flow rates.

[159] J. Waqas and T. Tingsanchali. (2016). "Sediment Flushing Strategy for Reservoir of Proposed Bhasha Dam, Pakistan." *2nd World Irrig. Forum*. Chiang Mai, Thailand, **Exhibit P-0679**.

[160] E. Atkinson. (1996). *The Feasibility of Flushing Sediment from Reservoirs*. 99. Report to British Overseas Development Admin. London, **Exhibit P-0680**.

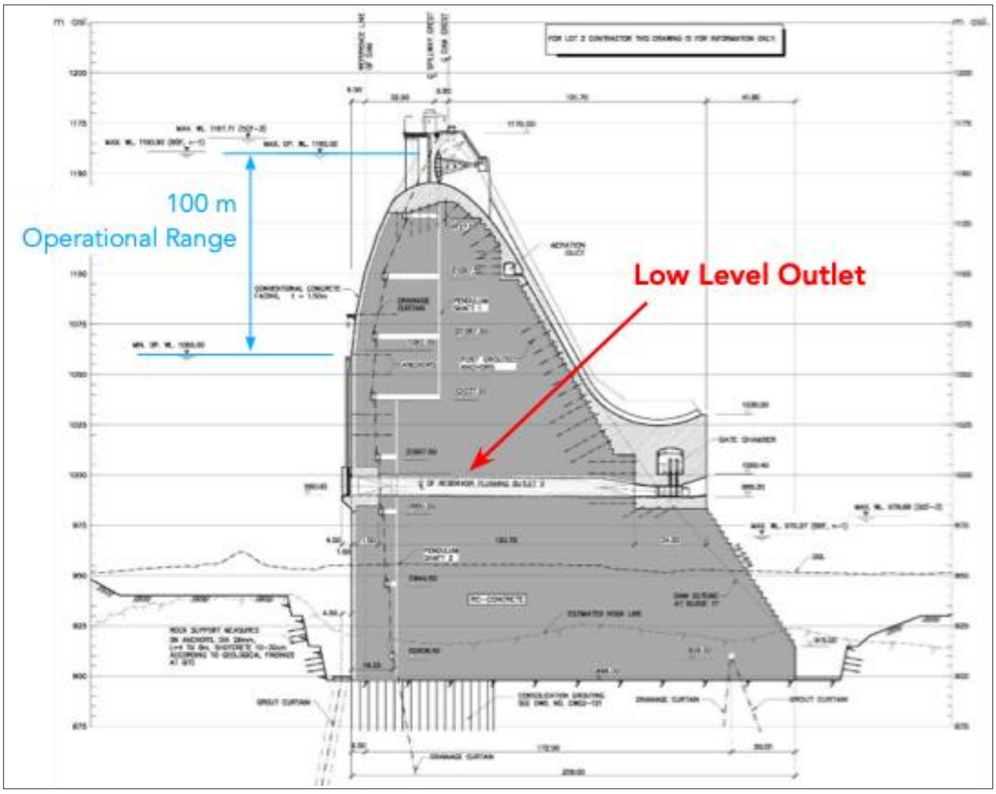

Figure III.5 - Schematic Section of Diamer-Basha Dam Illustrating the Location of the Low-level Outlet for Flushing (Haq and Munir 2009).[161] This Design has More Recently Been Modified to Eliminate the Crest Gates due to More Stringent Earthquake Criteria.

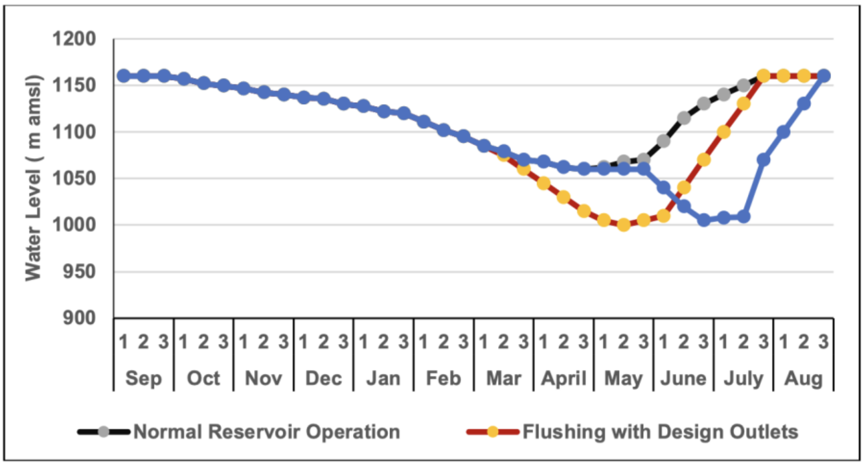

Figure III.6 - Alternative Operating Schedules for Diamer-Basha Comparing Normal (No Flushing) Against 31-day Flushing on Two Different Dates (Waqas and Tingsanchali (2016)).[162]

[161] I. ul Haq and K. Munir. (2009). "Role of Hydropower in Management of Power Crisis in Pakistan." *Pak. Eng. Congr.*, 19–34. Lahore: Pakistan Engineering Congress, **Exhibit P-0681**.
[162] J. Waqas and T. Tingsanchali. (2016). "Sediment Flushing Strategy for Reservoir of Proposed Bhasha Dam, Pakistan." *2nd World Irrig. Forum*. Chiang Mai, Thailand, **Exhibit P-0679**.

Scenario	Flushing Discharge (Cumecs)	Flushing Level (m amsl)	Flushing Period	Flushing Interval (Year)	SBR	LTCR
1	1,453-3,071	1,000 to 1,010	11 May-10 June	10	0.52	0.44
2	1,453-3,071	1,000 to 1,010	11 May-10 June	5	0.62	0.41
3	1,453- 3,071	1,000 to 1,010	11 May-10 June	1	0.75	0.45
4	5,130 -6,300	1,005 to 1,010	21 June-20 July	1	0.96	0.48

SBR = Sediment Balance Ratio, outflow/inflow.
LTCR = Long Term Capacity Ratio, sustainable capacity/original capacity.

Table III.2 - Flushing Scenarios Tested by Waqas and Tingsanchali (2016),[163] footnotes added for clarity.

III.28 **Commentary on Diamer-Basha**. With reference to the values for the SBR and LTCR ratios given in **Table III.2**, the relatively small range of differences in the LTCR values for all the scenarios, a range of 0.41 to 0.48, suggests that there is a relatively small difference between these different management methods. However, there is a significant difference in the SBR ratio. For example, if one compares Scenarios 1 and 4, the LTCR values are 0.44 vs. 0.48, a relatively small difference. However, Scenario 1 is only discharging 52% of the inflowing sediment load whereas Scenario 4 is discharging 96% of the inflowing load. This indicates that, over time, the reservoir will continue to accumulate very large quantities of sediment under Scenario 1, and the LTCR will progressively diminish over time. Because these simulations were conducted for only an 80-year period, the results in **Table III.2** do not represent the stable long-term condition. The tabulated results are for a simulation period that is not long enough to allow the reservoir capacity to stabilise under each alternative.

III.29 As an additional comment, the SBR value is higher for Scenario 2, flushing twice per decade, as compared to Scenario 1 with once per decade flushing. This is as expected. However, the LTCR values are reversed, with the twice per decade simulation (Scenario 2) sustaining a smaller reservoir capacity (smaller LTCR) than flushing only once per decade. This result does not seem reasonable, but no further comment can be made on this aspect from the limited information provided in the paper.

[163] *Id.*.

V. MANGLA RESERVOIR ON THE JHELUM

III.30 Pakistan's large Mangla storage reservoir is located on the Jhelum. It began operating in 1967, irrigates about 6 million Ha of land, and has 1310 MW of installed hydropower capacity. The average sediment load entering Mangla reservoir is 55.6 Mt/yr from its 33,397 km^2 watershed, resulting in a specific sediment yield of 1,665 $t/km^2/yr$. The long-term rate of storage loss is 37 Mm^3/year (Khan et al. (2020)),[164] and its original capacity of 7.25 Bm^3 had declined by 1.67 Mm^3 by year 2012. At this site the dam was raised to provide more capacity, offsetting (temporarily) the impact of sedimentation. Justification for this dam raise was discussed by Hashmi et al. (2009).[165] To offset the impacts of sedimentation, construction work began in 2004 to raise the dam by 12 m, increasing the gross storage to 9.12 Bm^3 without counting the storage loss by sedimentation (Sheikh (2012)).[166] Based on the average rate of storage loss, the 2025 capacity of Mangla reservoir will be about 6.97 Bm^3.

III.31 The potential impact of climate change and future land use changes on future sediment yield was studied by Aslam and Yoshimura (2017)[167] using the Universal Soil Loss Equation (USLE) methodology to quantify soil loss. The USLE erosion model was calibrated against sediment rating curves from river gauging stations. They found that most sediment entering the reservoir originated in the western (lower elevation) portion of the watershed due to rain falling on erodible soils, rather than originating in the snow-dominated higher watershed. If climate change increases rainfall this would produce a greater increase in sediment yield, and would have a more important impact on sediment yield than the impact of current trends of increasing land use intensity, primarily for agriculture. While increased precipitation and expansion of agriculture was expected to increase sediment yield, land use changes which enhanced vegetative cover would reduce sediment yield. They concluded that:

> Collectively, land use and climate change has potential to increase the sediment yield by 17% in late 21st century.[168]

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[164] M.A. Khan, et al. (2020). "Simulating the Impact of Climate Change with Different Reservoir Operating Strategies on Sedimentation of the Mangla Reservoir, Northern Pakistan." *Water*, 12 (10): 2736, **Exhibit P-0682**.
[165] H.N. Hashmi, et al. (2009). "Optimization of Mangla Reservoir Capacity by Raising Dam Height." *33rd IAHR Congr. Water Eng. Sustain. Environ.,* **Exhibit P-0683**.
[166] M.S. Sheikh. (2012). "Mangla Dam - Past, Present & Future." *Pak. Eng. Congr. Centen. Celebr. 1912 – 2012*, 131. Lahore, **Exhibit P-0684**.
[167] M.H. Aslam and K. Yoshimura. (2017). "Sediment Yield in Jehlum River Basin With and Without Climate Change Impact in Pakistan." *J Jpn. Soc. Civ. Eng. Hydr Eng*, 73 (4): I_85-I_90, **Exhibit P-0685**.
[168] *Id*., p. I_89.

III.32 Aslam and Yoshimura further estimated the useful life of Mangla reservoir as 110 years under present climate and land use conditions, together with reservoir trap efficiency calculations. It was concluded that climate change could reduce the useful life to 99 years, but the adaptation of measures such as reforestation of more fragile landscapes could extend the useful life to 130 years. These values were computed without considering sluicing or any other sediment management activities in the reservoir.

III.33 A study by Hussain et al. (2018)[169] used the Soil and Water Assessment Tool ("**SWAT**") erosion model to analyse the impact of land use change on sediment yield, comparing a worst case scenario to the existing land use trend. Climate change was not incorporated into this study. They concluded that:

> The current modest trend on the land use change does not have substantial effect on sedimentation in the Mangla Reservoir: an increase of 0.42% in sedimentation on a mean monthly basis by 2035, and an increase of 0.70% by 2060, are to be expected. However, in the worst-case scenarios, where a large scale deforestation is to occur, with a complete transformation of forest areas to cultivable ones, substantial increases in the sedimentation rate are expected: 1.3% for the scenario of 15% deforestation and 2.05% for the scenario of 21% deforestation by 2035 and 2060, respectively.[170]

III.34 These studies showed that to reduce the sediment load on Mangla reservoir, the conversion of forested areas into agricultural lands should be discouraged. They concluded that the reforestation of marginal lands can be an important factor to offset accelerated erosion due to the combination of increasing land use intensity plus climate change.

III.35 With respect to reservoir sedimentation, two types of problems are faced by the Mangla reservoir. **First**, there is the problem of capacity loss. **Second**, because the Jhelum River enters the main reservoir only 8.5 km upstream of the power intake, as seen in **Figure III.7**, the delta can reach the power intake much more quickly than if the delta began growing from the most distal area of the main reservoir. To address this second problem, delta advance toward the dam and power intakes, the option of gradually increasing the minimum operating level to retard delta advance along the Jhelum was evaluated by Khan et al. (2020).[171] Their analysis

[169] I.A. Hussain, et al. (2018). "Impacts of Land Use Change on the Sedimentation of the Mangla Reservoir, Pakistan." *Hydrolink*, 3: 89–91, **Exhibit P-0686**.
[170] *Id*., p. 91.
[171] M.A. Khan, et al. (2020). "Simulating the Impact of Climate Change with Different Reservoir Operating Strategies on Sedimentation of the Mangla Reservoir, Northern Pakistan." *Water*, 12 (10): 2736, **Exhibit P-0682**.

using the HEC-RAS 1D sediment transport model was summarised as follow:

> The results show that a gradual increase in the reservoir minimum operating level slows down the delta movement rate and the bed level close to the dam. However, it may compromise the downstream irrigation demand during periods of high water demand.[172]

III.36 This is the identical strategy previously described at Tarbela to retard delta advance toward the intakes. With a little over 20% of the watershed falling within Pakistan, WAPDA is also focusing on watershed management activities in these areas close to the reservoir. These activities include reforestation, check dam construction, and promoting better soil conservation practices.

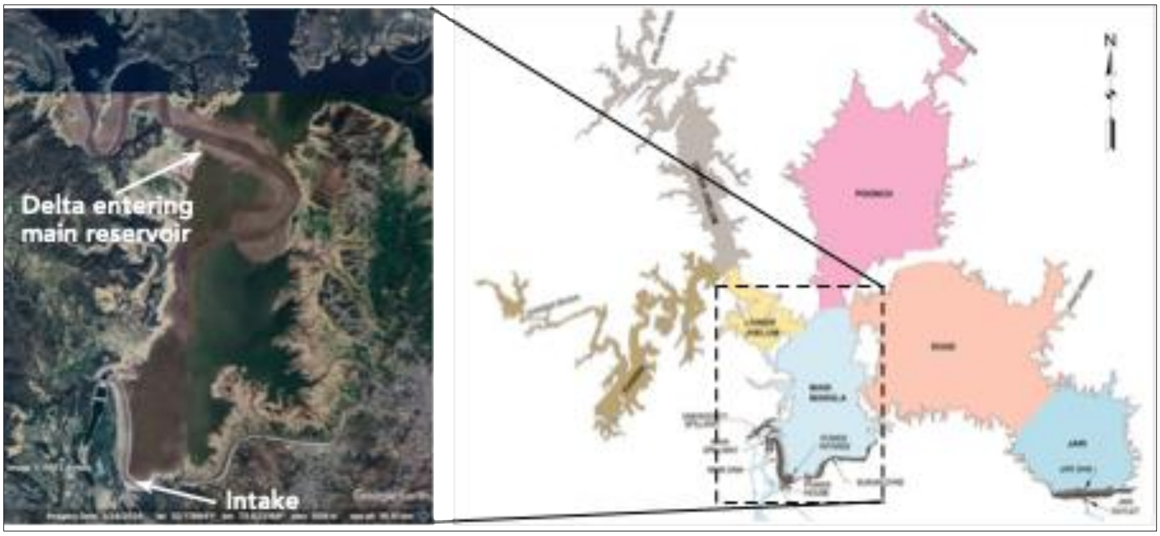

Figure III.7 - Jhelum River Enters Mangla, 8.5 km Upstream of the Power Intake[173]

III.37 A study by Raza et al. (2015)[174] focused on reservoir drawdown for flushing. Their analysis was conducted using the RESSASS 1D model to evaluate different flushing alternatives, including different start dates. They summarised their results as follows:

> The results indicate that the raising of dam will cause in reduction of delta advancement and sediment deposition rate which shall extend life of reservoir up to 2130 without any flushing option. Based on model study results, it revealed that maximum benefits in terms of power and irrigation could be achieved by 150 days flushing after each 10

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[172] *Id*., abstract.
[173] Photo from Google Earth (last accessed 24 March 2025). Graphic from M.S. Sheikh. (2012). "Mangla Dam - Past, Present & Future." *Pak. Eng. Congr. Centen. Celebr. 1912 – 2012*, 131. Lahore, **Exhibit P-0684**, p. 142.
[174] R.A. Raza, et al. (2015). "Exploring Sediment Management Options of Mangla Reservoir using RESSASS." *Sci.Int.(Lahore)*, 27 (3): 3347–3352, **Exhibit P-0687**.

years. This scenario also extends the life of the reservoir for another 40 years.[175]

III.38 **Commentary on Mangla**. It should be pointed out that a 150-day flushing period every 10 years, as indicated in the simulation by Raza et al. (2015) is not likely to be a viable management option for such a critical reservoir, not to mention that the infrequency of the event would release massive sediment pulses downstream once each decade, which would be much more disruptive than a more measured release schedule. Also, to achieve only a 40-year time extension of reservoir utility by flushing seems quite low, suggesting that more effective flushing or sluicing schedules may exist. On the other hand, Mangla reservoir has an unusual non-linear geometry, unlike other Indus reservoirs which tend to be long and narrow, and this will unfavourably influence the feasibility of sustaining long-term capacity at this reservoir by flushing.

VI. STUDIES IN THE CHENAB RIVER

H. CHENAB RIVER – SALAL PROJECT

III.39 The Salal hydropower project was the first major hydropower project on the Chenab; construction started in 1970 and it entered service in 1987. It has no Pondage and no desilting basin, which is in accordance with the configuration proposed to Pakistan by India via letter dated 30 April 1970, issued by then-ICIW B.S. Bansal, which reads in part:[176]

> The full pondage level of the reservoir is EL. 1600 ft. [487.7 m] The project has been designed to operate purely on a <u>run-of-river</u> basis, utilizing the river flows as available at the site, and at base load. Accordingly the pond level will be maintained constant at EL. 1600 ft., excepting during periods of floods when it may rise up to the designed maximum flood level of EL. 1610 ft.
>
> | | |
> |---|---|
> | Full Pondage Level | EL. 1600 ft. |
> | Dead Storage Level | EL. 1600 ft. |
> | Operating Pool | Nil |
>
> Dead storage capacity 230,303 acre ft. [284 Mm^3]

III.40 It was not many years before sediment presented a serious problem, with sedimentation accelerated by severe floods in 1988 and 1992, resulting in sediment accumulation up to the

[175] *Id.*, p. 3347.
[176] Letter No. F.4(10)/63-IC from the ICIW to the PCIW, 30 April 1970, **Exhibit P-0649.0169 (resubmitted)**, p. 3 (emphasis added).

spillway crest level within 5 years (Darde (2016)).[177] Sediment management practices adopted at Salal were described as follows by Joshi et al. (2021):

> - The Salal reservoir had initial reservoir capacity of 284 MCM, which reduced drastically in initial few years of operation. Subsequently following guideline has been adopted.
> - When the sediment concentration is more than 3500 ppm and / or discharge crosses 2500 cumec (1500 cumec in September). Power house is shut down and flushing is being carried out through spillway gates to pass the excessive silt laden water.
> - From May to August, if discharge does not exceed 2500 cumec (1500 cumec in September), then flushing is carried out on the last day of each month irrespective of discharge.
>
> Since past 15 years, the reservoir capacity of reservoir has been maintained at around 12-13 MCM.[178]

III.41 Kumar and Singh (2022) described sedimentation of the Salal project as follows:

> Salal Hydropower Station on river Chenab comprises of 113 m high concrete dam and 118 m rockfill dam, giving rise to a reservoir of 280.85 MCM storage capacity. The reservoir was silted up fast, losing almost whole of storage capacity in initial five years, due to excessive silt inflow and two high flood events.[179]

III.42 **Commentary on Salal**. Although the 1970 letter from the ICIW indicated that Salal was to be built as a run-of-river Plant operated at a constant water level, India constructed the plant with low-level outlets, which were subsequently blocked off in response to objections by Pakistan. However, it seems unusual that the Salal HEP would be proposed for operation at a constant high water level, without providing some type of desilting arrangement, since the need for desilting at run-of-river Plants was certainly well known at that time.

III.43 On the other hand, it is interesting that it is possible to maintain about 12 to 13 Mm^3 of capacity in this reservoir under its current configuration, despite closure of the low-level spillway outlets. Unfortunately, Pakistan does not have any information on the actual operation of this reservoir, for example, the extent and duration of any drawdown in the water level for

[177] P.N. Darde. (2016). "Detrimental effects of tiny silt particles on large hydro power stations and some remedies." *Perspect. Sci.*, 8: 142–145, **Exhibit P-0688**.
[178] B. Joshi et al. (2021). "Sediment Management Practices in NHPC's Power Stations." *ICOLD 2021 Workshop Sediment Manag. Reserv. Sustain. Dev,* **Exhibit P-0662**, p. 5.
[179] V. Kumar, and A. K. Singh. (2022). "Sediment Management for Reservoir Based hydropower Projects." *Intl Conf Hydropower Dams Dev. Water Energy Secur. – Chang. Clim.* Rishikesh, India, **Exhibit P-0670**, p. 2.

sediment management or any other purpose.

I. CHENAB RIVER – BAGLIHAR PROJECT

III.44 Baglihar HEP is located 48 km upstream of Salal HEP on the Chenab River. It began operating in 2008 with a design gross capacity of 396 Mm^3 and an ultimate generating capacity of 900 MW. Civil design characteristics have been summarised by Bhardwaj et al. (2015)[180] and in their presentation they made the provided the following description of project design and operation related to sediment management:

> The reservoir behind the dam will function as a sedimentation tank. The coarser sediment will, therefore, settle in the reservoir till it is silted up to the spillway crest level (El 808.0m). The inlet level of the intake has been kept at El 818.50m so that even after the silting of the reservoir up to 808.0 m level, most of the bed load from the flow will be flushing out by suitable operation of the spillway gates. The level of gate sill for the intake gates has been kept further higher by 2.5m i.e. at El 821.0. The minimum pond level has been fixed at El. 836.0 m. The intake have its invert at El. 821.0 m which is 13 m above the crest of sluice spillway. With this level, sufficient cushion is available for preventing the sediment in the reservoir from entering the Head Race Tunnel. As such the water drawn by the intake will be practically sediment free even when the reservoir is silted up to the spillway crest.[181]

III.45 A sedimentation study at Baglihar was undertaken using the Mike 11 model by DHI (2006) on behalf of India's Central Water Commission. This was shared with Pakistan during the *Baglihar* Neutral Expert proceedings.[182] The analysis incorporated the low-level outlet at 808 m, but the reservoir was not drawn down below India's proposed DSL elevation of 835 m, resulting in an Operating Pool 5 m deep (between 835 m and 840 m elevation). Results of that simulation are presented below as **Figure III.8** showing the advance of the delta toward the dam, and also showing that the bed remained below the 835 m level. This modelling indicated sediment would reach the spillway in about 30 years. A long-term (100-year) simulation was also presented, reproduced below as **Figure III.9**, which demonstrated that sluicing could sustain the Operating Pool with a stable sediment profile over a 100-year period.

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[180] S. Bhardwaj, et al. (2015). "A Review on Baglihar Hydroelectric Project." *SSRG Int J Civ. Eng.*, 2 (3): 22–27, **Exhibit P-0689**.
[181] *Id*., p. 24.
[182] DHI, 'Baglihar Reservoir Sedimentation Study', **Exhibit P-0547/BR-0021**.

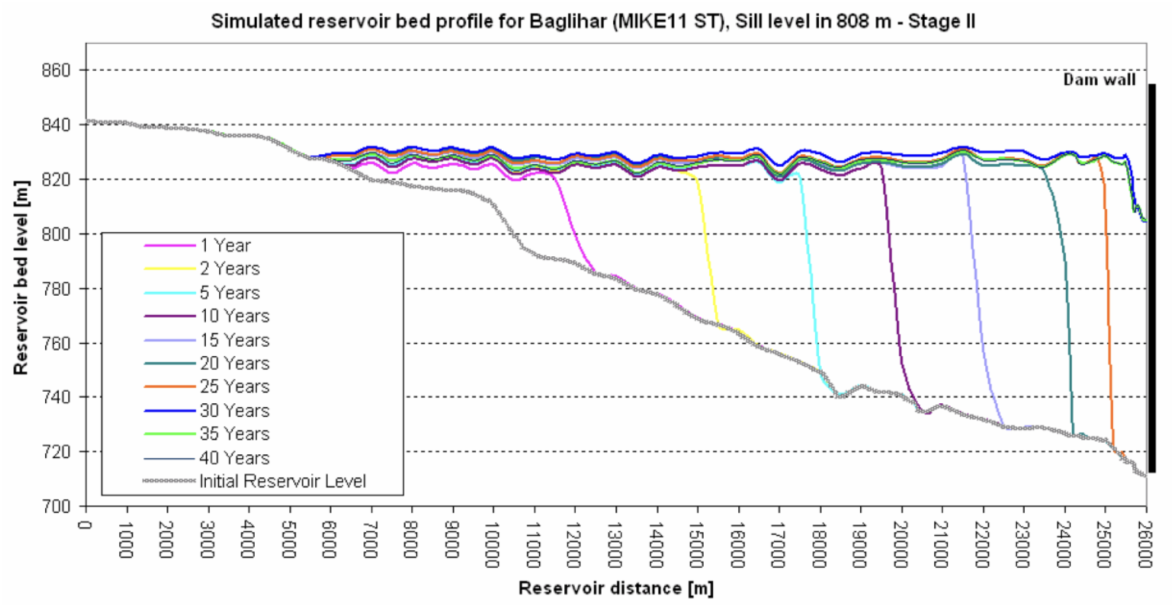

Figure III.8 - Long-term Sedimentation Profiles for Baglihar Reservoir (Reproduction of Figure 4.10 from DHI (2006)[183]).

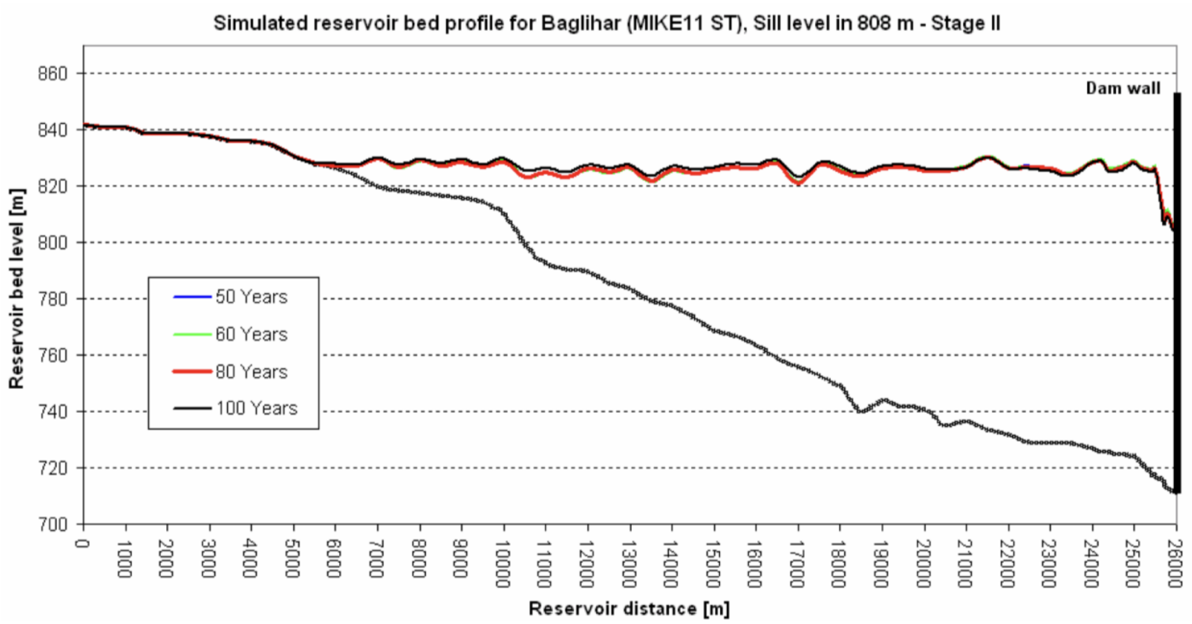

Figure III.9 - Long Term (100-year) Simulation of Sluicing in Baglihar Reservoir Showing Stabilisation of the Sediment Profile while Preserving Pondage (Reproduction of Figure 4.11 from DHI (2006)[184]).

III.46 The study published by Lade et al. (2015)[185] concluded that, absent sediment management, it would require 50 to 60 years for Baglihar to fill with sediment. With respect

[183] *Id.*, p. 28.
[184] *Id.*, p. 29.
[185] A. Lade, et al. (2015). "Feasibility of Sluicing Operations for Run-Of-River Schemes in Himalayan Region." *IOSR J Mech. Civ. Eng*, 13 (1), **Exhibit P-0690**.

to sediment management they concluded that sediment sluicing is the most effective method to control sedimentation, given the widespread objection to flushing due to the "immense damage" caused downstream of the dam. They made the following observations:

> Drawdown flushing has been found to work optimally on narrow, gorge shaped reservoirs where water can be fully drawn down. Dredging, the most commonly used sediment management technique, is a highly expensive and time consuming practice, although efficacious when complimented by other methods, particularly for settling basins at the inlet of the reservoir. Also due to drawdown flushing there is immense damage caused on the downstream side of the reservoir, thus now days it is not permitted to be carried out by the government.
>
> Hence considering all the limitations and advantages of the above mentioned methods the most effective method to control the problem of sedimentation is sluicing which is a new technology and is greatly effective for the rivers in the Himalayan region where there is a great problem related to collection of sediments on the upstream side of the reservoirs. During the sluicing process, sufficient amount of water is available on the upstream side of the reservoir and hence continuous generation of hydroelectricity can be done without stoppage.[186]

III.47 Sluicing was described as follows:

> Sluicing is a way of abating sediment deposition in the reservoirs. In this method, the reservoir level is drawn down during the flood season and water is allowed to flow through the sluice gates to maintain the incoming sediment in suspension.[187]

III.48 General operational requirements for sediment management for the hydropower projects in the Himalayan region to achieve continuous functioning and production of hydroelectricity were listed as follows:

> i. Continuous supply of water is required for generation of electricity, which would have not been available if flushing was to be carried out for the purpose of removing the sediments.
>
> ii. Inflow of sediments should be equal to outflow i.e. equilibrium condition should be maintained. The level of sediment deposited should not affect the intake of reservoir.
>
> iii. The water level should not go below MDDL i.e. maximum drawdown level which is the minimum head required for harnessing the hydropower.
>
> iv. The sediments discharged should cause minimum disturbance on the downstream side. All these requirements can be fulfilled by the process of

[186] *Id.*, p. 4.
[187] *Id.*.

sluicing and hence needs to be studied in detail.[188]

III.49 A recent modelling study of sedimentation in Baglihar is reported by Nouman (2020)[189] but there is a question concerning authorship of this document. Except for the change in the title, author, publication date, and text formatting, this document (both text and figures) is an exact copy of the thesis previously prepared by Irfan (2015) at Delft University.[190] A copy of Irfan's thesis was obtained directly from the university at Delft. The discussion below refers to the original thesis by Irfan as obtained from Delft.

III.50 The Irfan thesis[191] provides data regarding the Baglihar site, including data obtained from NESPAK and other sources. This study predicted that the useful life of the Baglihar HEP reservoir will be about 50-60 years, absent sediment management. However, beyond this the study analysed hypothetical rather than actual conditions, and this limits its utility for our present purpose. Specific departures from the actual project configuration and operation are outlined below.

III.51 The "normal operation" is simulated by modelling a baseline Scenario-1, but it is not clear what this scenario consists of. The range of water levels at the downstream boundary of the model are reproduced below as **Figure III.10**, yet the range of water levels from 820 to 840 m shown in the graph does not accord with the levels for the Operating Pool (835.9 to 840 m).

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[188] *Id.*, p. 5.
[189] M. Nouman. (2020) "Analysis of Silt Transport, Deposition and Its Management in the Reservoirs Built on Run-off the Rivers Case Study: Modelling of Silt Flushing through Sluice Gate in Baglihar Hydroelectric Generation Plant, India" (Thesis), **Exhibit P-0665**.
[190] M. Irfan. (2015). "Sediment Management in Reservoirs Built on Run-of-rivers: [case study: Modelling of Silt Sluicing Through Under Sluice Spillways in Baglihar Hydropower Dam, India]." M.S. Thesis. Delft, Netherlands: IHE Delft, **Exhibit P-0666**.
[191] *Id.*.

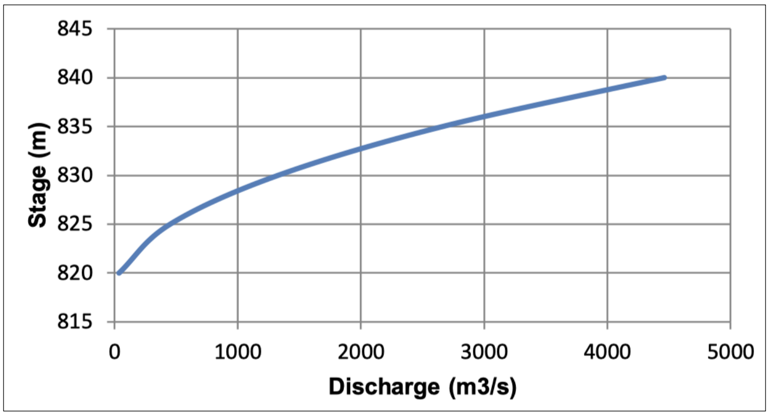

Figure III.10 - Reproduction of Figure 5.4 of Irfan (2015) Titled, "Rating Curve Used in HEC-RAS as a Downstream Boundary Condition."[192]

III.52 **Figure 6.1** of the paper (reproduced below as **Figure III.11**), shows a water level of approximately 813 m on 1 January 2017, which is below the level required to operate the turbines. This would not be a normal operational level at any time of the year, and certainly not in January.

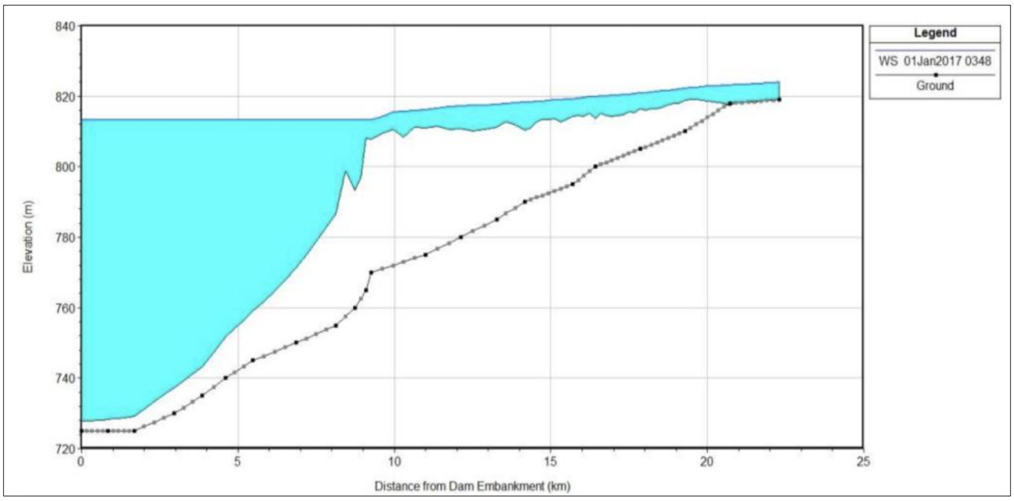

Figure III.11 - Reproduction of Figure 6.1 of Irfan (2015) Titled, "Change in Bed Profile of Baglihar Reservoir Based on 10 Years of Sedimentation."[193]

III.53 A second "hypothetical" simulation scenario was described as follows:

> The second simulation was conducted under a hypothetical operational scenario of reduced water levels by using bottom outlets.[194]

III.54 As seen in **Figure III.12,** this second simulation produced almost no sedimentation, a

[192] *Id.*, p. 40.
[193] *Id.*, p. 45.
[194] *Id.*, p. 47.

condition consistent with fully emptying the reservoir through bottom outlets located near the river bed. However, Baglihar does not have bottom outlets near the river bed; the outlets are higher up on the face of the dam. These departures from reality indicate that this modelling study of hypothetical conditions reflects neither the existing physical configuration nor the operational conditions at Baglihar.

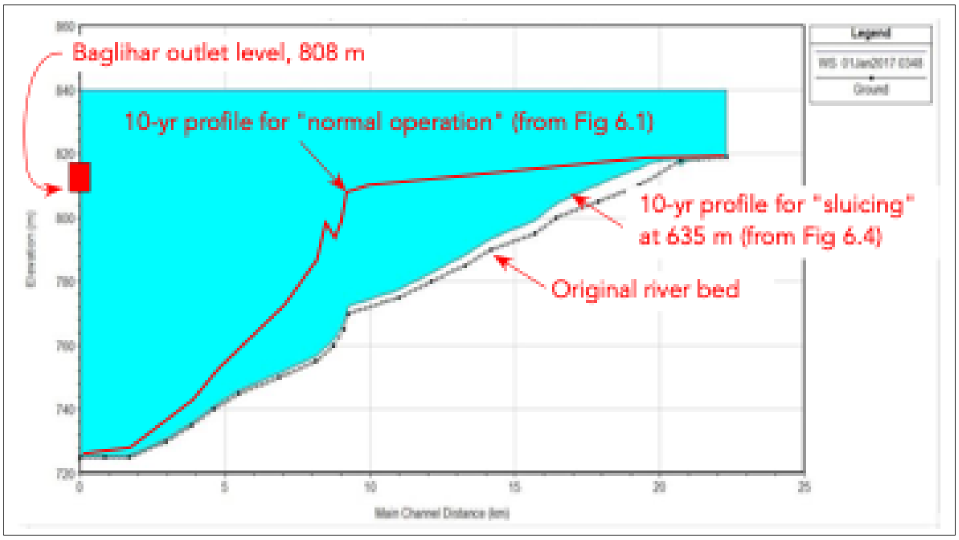

Figure III.12 - Reproduction of Figure 6.4 of Irfan (2015) Titled, "Change in Bed Profile of Baglihar Reservoir under Sluicing Operation Based on 10 Year's of Sedimentation,"[195] with Annotations Added in Red.

III.55 The most recent public domain modelling study to analyse future sedimentation conditions at Baglihar and the impact of flushing is reported by Kumar et al. (2021).[196] However, a review of this article reveals a number of discrepancies which render its results unreliable.

III.56 **Storage loss.** The article summarises results of the storage loss analysis without sediment management as follows:

> The results of reservoir capacity changes due to sedimentation for a long time period show that after 100 years the reservoir will lose 40% of its initial volume.[197]

III.57 These results are entirely unrealistic, contradicting the prior studies, contradicting the studies done by both India and Pakistan in the course of the *Baglihar* Neutral Expert

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[195] *Id.*, p. 47.
[196] R.A. Kumar, et al. (2021). "Sediment Budget and Sediment Trap efficiency of Baglihar Hydroelectric project Reservoir – a calibrated model for prediction of longevity of the Dam." *J. Indian Assoc. Sedimentol.*, 38 (1), **Exhibit P-0664**.
[197] *Id.,* p. 72.

proceedings, and also contradicted by our own updated analysis in **Annex II**.

III.58 **Flushing calculations**. The paper also reports the results of a flushing analysis, stating that:

> By applying flushing schemes, life of the reservoir can be reasonably increased; after 100 years the reservoir will lose only 35.6% storage volume.[198]

III.59 It is unclear what type of flushing scheme the article contemplates and how its effectiveness was calculated. Based on the above quote, the paper's authors attribute only a 4.4% capacity change when comparing conventional operation against a flushing operation (40% vs. 35.6% capacity loss). This is also unrealistic, since an effective flushing operation can essentially halt sedimentation once the long-term scour geometry has become stabilised. These fundamental modelling errors indicate the analysis to be flawed and the results unreliable.

III.60 **Additional errors**. The article has another glaring error. The graph of the variation in 10-day flows over time, reproduced below as **Figure III.13,** has a fundamental error. The "maximum" values are (correctly) plotted as the **highest** values during part of the year, but are (incorrectly) plotted as the **lowest** values during other months of the year. Similar problems occur with the "minimum" and "average" lines. This basic error in the plotting of minimum, maximum and average values is another indication of technical deficiencies.

III.61 In summary, the results presented in this paper cannot be relied upon.

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[198] *Id.*.

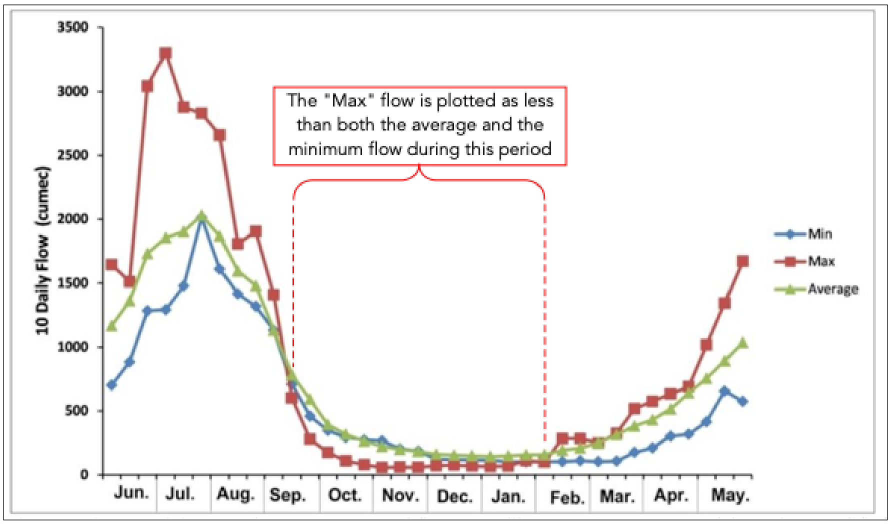

Figure III.13 - Reproduction of Figure 3 from Kumar et al. (2021)[199], Annotated to Highlight Errors in the Graphing of Maximum, Minimum and Average Flow Rates.

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[199] *Id.*.

[200] For the purposes of paragraph 2.8 of PO14, an extensive literature review was undertaken. The studies addressed herein, however, are restricted to those which are current, up-to-date and have not been superseded by subsequent analyses. A further hundred or so other potentially relevant studies in the public domain were reviewed but it was concluded that they were not ultimately relevant or applicable, and they are accordingly omitted from this list of references.

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